Notes

Atomic Energy Control Board | Commission de contrôle de l'énergie atomique

INFORMATION BULLETIN 90-2 **May 15, 1990**

REGULATORY RESEARCH & SUPPORT PROGRAM FOR 1990/91 -- PROJECT DESCRIPTIONS

The Regulatory Research & Support Program (RSP) is intended to augment and extend the Atomic Energy Control Board's regulatory program beyond the capability of in-house resources. The overall objective of the research & support program is to produce pertinent and independent information that will assist the Board and its staff in making correct, timely and credible decisions on regulating nuclear facilities and materials.

The program is divided into eight main areas of research covering the safety of nuclear facilities, radioactive waste management, health physics, physical security and the development of regulatory processes. A total of 95 projects are planned for 1990/91, including a number which are ongoing from the previous fiscal year. Projects that are held in reserve in case funding becomes available are also listed. Although the spending estimates for the RSP were calculated on the basis of an expected budget of $3.75 M, it appears, as of the date of issuance of this Bulletin, that the final budget for the RSP for 1990/91 will be about $3.50 M.

Most of the projects will be carried out under contracts issued through the Department of Supply and Services.

This Information Bulletin contains a list of the projects with a brief description of each, and additional supporting information.

Additional copies of this Bulletin, or other information concerning its contents, may be obtained by contacting:

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REGULATORY RESEARCH & SUPPORT PROGRAM 1990/91

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EXPLANATION OF PROJECT DESCRIPTIONS

A. PROJECT NUMBER (unique to project)

- first digit	number of the Mission Object (see main headings in "List of 1990/91 Projects", numbered from 2. Nuclear Reactors to 9. Regulations and Regulatory Process Development)
- second set of digits	item number (beginning nominally with number 101) within the Mission Object
- third digit	contract or phase number in a sequence of related contracts for a given item number (e.g., a full-scale study [2] following a feasibility study [1]). The number 1 appears even if a project is not subdivided into phases.

B. TITLE

C. SUMMARY
The three paragraphs state:
- WHAT is proposed or in progress and by what means
- WHY this project is proposed
- HOW it is intended to use the results.

The participation, if any, of other organizations is also mentioned.

D. PROPONENT
Originating division within the AECB, or other originator, of the proposal. (Abbreviations refer to AECB organizational units, whose full names are given under "Standard Abbreviations, AECB Organizational Units".)

E. TECHNICAL ADVISOR/EVALUATOR
AECB division (and individual staff member, where known) which gives advice to, or for liaison with, the Project Manager on certain technical aspects of the project. The evaluator assesses the quality of the work done by the contractor and also assesses how the results of the project may be used by the AECB, through a post-project evaluation.

F. PROJECT MANAGER
Name of staff member within the Research Sections responsible for the project (to the extent that the AECB is committed, in the case of joint projects).

G. REVIEW PANEL
The Review Panel is a group of internal and external experts set up by the AECB to give advice to the Project Manager on some or all technical aspects of the project. A panel is automatically included in the post-project evaluation, even if not so shown in block E.

H. CONTRACTOR
For projects in progress, the name of the company or institution doing the work is given.

I. PRINCIPAL INVESTIGATOR
If known, the name of the principal investigator is given.

J. CATEGORY
1* - Projects in progress at the beginning of the program year (from preparation of work statement to acceptance of final report).
1 - Projects intended to be initiated in the program year.
2 - Projects which would be Category 1 but depend on the outcome of other work, e.g., on the results of a feasibility study.
3 - Projects deferred to next or subsequent years or held in reserve in the event that funds become available in the program year.

K. FUNDING

Past Years	Year Prior to Program Year	Program Year	Year after Program Year	Future Years	Project Total

- Actual expenditures are shown for past years.
- Budgeted amount is shown for the program year; but this amount is subject to change. For Categories 2 and 3 items the amount may be quite speculative.
- Amounts shown for years after the program year can be very speculative.

L. RELATED PROJECTS
Earlier directly-related projects are shown by project number along with the previous expenditures, by year, on such projects. Directly-related projects may be literature reviews, in series.

1990/91 PROJECT DESCRIPTIONS

CATEGORIES 1*, 1 AND 2

1990/91 Research Projects
Categories 1*, 1 and 2

2.102.1	CASE Analysis Tools for Real-Time Software
2.111.1	International Piping Integrity Research Group
2.111.2	International Piping Integrity Research Group - 2
2.114.2	A Simulator for Evaluating Emergency Operating Procedures
2.127.5	Statistically Valid Random Testing for Real-Time Software
2.128.3	Review of a BNPD Fire-Fighting Exercise
2.130.2	Self-Testing of Programmable Controllers & Microcomputers
2.134.1	Estimating Software Reliability for Reactor Shutdown Systems
2.152.3	Tutorial Sessions for CATHENA Users
2.152.4	Five-Channel-per-Pass CATHENA Code for Darlington NGS
2.157.2	Detailed Analysis of Severe Accident Consequences
2.158.1	Evaluation of Software Functional Specification Review Techniques
2.162.2	Childhood Leukemia around Canadian Nuclear Facilities (Phase II)
2.175.1	Pump Cavitation and Piping Vibration (I)
2.176.1	Software Functional Requirement Specification Techniques
2.184.2	Ballooning of CANDU Pressure Tubes - Model Verification
2.191.1	Review of Piping System Failures at Discontinuities
2.195.1	Fracture Toughness of Fuel Sheath Material
2.196.1	Statistical Review of Pressure Tube Inspection Data
2.199.1	The Prevention, Mitigation and Accommodation of Water Hammer
2.200.1	A Safety Course for Pressure-Tube Type Reactors
2.202.1	Severe Accident Source Term
2.203.1	Intermediate and Full Scale Tests on Hydrogen Burn Phenomena
2.204.1	Pressure Tube Rupture in A Closed Tank - Thermalhydraulic Loadings
2.205.1	Training Requirements for Authorized Operating Personnel
2.206.1	Methodology for Assessment of Training Programs
2.207.1	Guidelines for Examination Time Allocation
2.209.1	Pickering Seismic Safety Margin (Feasibility Study)
2.210.1	Participation in the USNRC Severe Accident Research Program
2.211.1	Tritium Surface Contact Dosimetry
2.212.1	Analysis of Voice Communications
2.214.1	Review of Supervisory Functions in Nuclear Power Plants
2.215.1	Criticality Energy Release Rate in Uranium Solutions
2.216.1	Validation of Positive Void Effect
2.217.1	Seismic Monitoring East and North of Toronto
3.101.2	Demonstration of the Feasibility of Directly Dating Quartz (2)
3.106.3	Transfer of Radionuclides to Human Milk - Phase 3 Pilot Study
3.111.1	Evaluation of Data and Models on Uranium Metabolism - Europe
3.111.2	Evaluation of Data and Models on Uranium Metabolism - North America

3.123.1	Influence of Macrophages on Dissolution of Uranium Compounds
3.124.1	Assessment of Errors in Airflow Measuring Instruments (U Mines)
3.125.1	Study of Chemical Toxicity of Uranium Hexafluoride
3.133.1	Carbon-14 in Food and in Excretions
3.134.1	RBE from a Microdosimetric Approach
3.135.1	Measurement of Tritium in Canadian Food Items
3.139.1	Offset River Terraces in the Charlevoix Seismic Zone
3.144.2	Liquefaction Features in the Chicoutimi Area
3.148.1	Thorium Metabolism and Dosimetry - Literature Review
3.150.1	Different Biological End-Points to Study Radiation Effects
3.151.1	Canadian Data Base for Radionuclide Transfer in the Environment
3.152.1	Production of Public Information Material on the Effects of Radiation
3.155.1	Validation of Environmental Pathways Analysis Models
3.156.1	An Analysis of Brittle Structures in the Saguenay Earthquake Areas
3.157.1	A Field Evaluation of Convoluted Laminations
4.101.1	Study of the Health Effects of Inhaled Uranium Ore Dust
4.103.2	Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities
4.106.3	Ontario Miners Mortality Study - Phase III
4.106.4	Ontario Miners Mortality Study - Annual Update
4.108.1	Intercomparison of Aerosol Sampling Instruments
4.113.1	Tracer Gas Method for Assessing Ventilation Efficiency
4.117.1	Evaluation of Long-Lived Dust Exposures from Silica Samples
4.118.1	Evaluation of Exposure Records of Eldorado Uranium Miners
4.118.2	Mortality Analysis of Beaverlodge Uranium Miners from 1981-1987
4.119.1	Evaluation of Mine Ventilation Monitoring Devices
4.129.1	Temporal Variation of Airborne Radioactivity in Mines
5.127.1	Radionuclide Concentrations in Fish: Phase I Screening Program
5.134.1	International Conference on Transport Processes in Aquifers
5.135.1	Frost Evolution in Tailings
5.136.1	Hydrology of Quirke and Panel Tailings Basins
5.138.1	Review of Uranium Solubilities
5.139.1	Dissolution of Fuel Matrix - Analog Studies
5.140.1	Link between Ore Bodies and Biosphere Concentrations of Metals
5.141.1	Review of Groundwater Dating and Its Relation to High Level Waste Disposal
5.142.1	Feasibility of Monitoring Tailings Sites Using Remote Sensing
6.102.1	Radiation Doses to Technologists from Radiotherapy
6.105.1	Radiation Exposures of Non-Monitored Hospital Personnel
6.113.1	Measurements of Radioactive Waste Disposal in Hamilton
6.114.1	Calculation of Lung Dose following Fluoroscopic Examination
6.114.2	Mortality Analysis of Persons Subjected to Fluoroscopic Examination
7.093.1	Epidemiology of Lung Cancer Mortality in Canadian Mining Communities

7.101.1	The Canadian National Dose Registry Study
7.106.2	Effects on Central Nervous System from In Utero Exposure
7.118.1	Selection of Control Groups for Epidemiological Studies
7.119.2	Full-Scale Epidemiological Study of Thyroid Cancer from I-131 Exposure
7.122.1	Computerized Linkage of National Cancer Incidence Data
7.135.1	Mechanism of Radiation-Induced Mental Retardation
7.137.1	Study of Childhood Cancer following Maternal X-Irradiation
7.141.1	RBE of Gamma Rays Delivered at Low Dose Rates
7.152.1	Transport of Compounds from Mother to Foetus
7.153.1	RBE of Tritium and Co-60 Gamma Rays at Low and High Dose Rates
9.103.2	Implementation of a New File Classification System
9.103.3	Implementation of New Information Management Plan
9.106.2	A Review of the UCP System
9.116.1	The Concept of "Environment" in a Legal Context
9.117.1	Development of a Security Program for EDP at the AECB

2. NUCLEAR REACTORS

2.102.1 CASE Analysis Tools for Real-Time Software

A project is proposed to survey the latest developments in computer program analysis and testing, using graph theory as applied to real-time critical systems. Then, based on the results of the survey, it is proposed to acquire or develop a program graphing software tool to analyze the complexity and verification/validation test coverage aspects of safety-related nuclear system software.

Due to the combination of the number of inputs and processing pathways, computer programs used to control nuclear reactor systems are very difficult to verify and validate to an acceptable degree of confidence. Even using extensive test data some design and programming faults may go undetected resulting in the possibility of a critical failure at some future time given a certain set of input and processing conditions.

The results of the survey phase would provide AECB staff with the latest information concerning analysis of critical software, enabling a knowledgeable assessment of the particular methods and test data used by licensees to verify and validate their nuclear software. The resulting software tool may provide an effective means for AECB staff to rigourously and independently evaluate the testability of a particular system and the extent of test coverage proposed by the licensee.

Proponent	SED, SSS
Technical Advisor/Evaluator	SED (R. Taylor, L. Tougas)
Project Manager	D.E. Connelly
Review Panel	12
Contractor	
Principal Investigator	
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$20k	$70k	$0k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

2.111.1 International Piping Integrity Research Group

It is proposed to continue membership in the International Piping Integrity Research Group (IPIRG). This group, organized by the U.S. Nuclear Regulatory Commission (USNRC), is examining the fracture behaviour of large piping systems. The proposed program by the USNRC includes: fracture tests done on approximately 60 large-diameter pipes, of which about one third are directly relevant to CANDU; material tests to establish a data base for fracture analysis; assessment of the efficacy of fracture calculations; review of degraded piping; and review of the state-of-the-art analytical and experimental developments. The cost of Canadian participation in the IPIRG program would be shared equally between AECB and Ontario Hydro (each contributing $300k US).

There is a need to develop and verify the technology to justify: using analytical assessments to disposition piping defects and prescribe inspection frequencies for them; permitting leak-before-break concepts in lieu of mechanical protection for hypothetical pipe ruptures; and current procedures for response to primary heat transport system leaks.

The results would be used to support, or change, the licensing criteria for protection against pipe rupture, to define in-service inspection frequencies, and to develop rules for reactor shutdown after leaks have been detected.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	USNRC/Battelle
Principal Investigator	M. Mayfield
Category	1*

Past	89/90	90/91	91/92	Future	Total
$132k	$129k	$140k	$0k	$0k	$401k

Earlier Directly-Related Contracts and Funding:

2.111.2 International Piping Integrity Research Group - 2

It is proposed to participate in Phase II of the International Piping Integrity Research Program (IPIRG-2) after the completion of Phase I (IPIRG-1) by mid 1990. In IPIRG-2, data will be obtained for both quasi-static and dynamic (seismic) loadings, and experiments will be conducted on piping configurations representative of actual piping systems. The new program will also include selected special-effect experiments in support of the pipe system experiments. The USNRC will be the lead organization, with multi-national contributions to the program. The cost of Canadian participation is expected to be shared equally between the AECB and Ontario Hydro (each contributing $360K over 4 years).

The current IPIRG program (IPIRG-1) will be completed by July 1990. The work which will be conducted in the new program (IPIRG-2) will build on the solid base of information that has been established in IPIRG-1. The new program will include testing of piping systems, including cracks in straight pipes, elbows and tees. Such information is crucial to assessing licensees' designs.

The information generated by this project would be used in assessing new design concepts such as leak-before-break, defining in-service inspection frequency, and evaluating licensing criteria for protection against pipe rupture.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	2

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$20k	$120k	$220k	$360k

Earlier Directly-Related Contracts and Funding:

2.105.1	$88500	$10000	$0			$98500
2.111.1	$261000	$119000	$21000			$401000

2.114.2 A Simulator for Evaluating Emergency Operating Procedures

A research project is proposed which would produce a series of computer modules which simulate the general dynamic features of a CANDU 600 MW reactor. The modules would "plug in" to the existing computer simulation environment which was acquired by project 2.114.1.

This project is prompted by a review of Emergency Operating Procedures (EOP) that indicated the need for an analytical tool to assist in understanding the interaction of various plant systems. For example, during a small loss of coolant accident involving the steam space above the pressurizer at low power, one would expect the pressure to drop quickly and the pressurizer level to drop by about 10% and then rise rapidly. At full power, the pressurizer level should rise as the pressure drops. Such an hypothesis could be tested with this simulation.

The simulation will be used to develop an understanding of the way in which a CANDU 600 MW reactor responds to various accident conditions. This understanding is required to evaluate the suitability of the form and diagnostics in an EOP.

Proponent	SED
Technical Advisor/Evaluator	SED (P. Wigfull)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$20k	$0k	$20k	$0k	$0k	$40k
Earlier Directly-Related Contracts and Funding:						
86.1.24	$30000	$0	$0			$30000

2.127.5 Statistically Valid Random Testing for Real-Time Software

It is proposed to develop a procedure for using statistical testing to evaluate the probability that a critical real-time software system (such as the proposed shutdown systems for Darlington Nuclear Generating Station) meet its requirements. This project is an elaboration of the preliminary recommendations made in projects 2.127.2 and 2.127.4 concerning statistical testing.

For safety-critical systems it is essential that an estimate of the upper bound of the probability of failure be determined before the system is placed in service. By applying N statistically valid, randomly selected test cases, we can determine the likelihood that a system with a probability of failure greater than a certain value would successfully pass the N tests. Then by selecting an acceptable upper bound for the probability of failure, the number of test cases required, N, can be derived and applied resulting in a tangible numeric estimate of the trustworthiness of the system.

The results of this work will assist AECB staff in preparing recommendations for regulatory actions concerning the trip computer software for the Darlington shutdown systems.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor, L. Tougas)
Project Manager	D.E. Connelly
Review Panel	
Contractor	
Principal Investigator	
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$30k	$45k	$0k	$0k	$75k

Earlier Directly-Related Contracts and Funding:

2.127.1	$31000	$0	$0		$31000
2.127.2	$67000	$5000	$0		$72000
2.127.3	$0	$13000	$37000		$50000
2.127.4	$8000	$0	$0		$8000

2.128.3 Review of a BNPD Fire-Fighting Exercise

A contract is proposed which would evaluate the Bruce Nuclear Power Development fire-fighting capability assessment program, using information obtained in the preliminary assessment (projects 2.128.1 and 2.128.2).

AECB staff is concerned that the capability of Ontario Hydro Bruce Nuclear Power Development (BNPD) site fire crews to cope with a major fire has not been fully assessed or exercised. In response to this concern, Ontario Hydro has made the commitment to determine the adequacy of the fire fighting capability at the individual stations of the BNPD site. The AECB requires an expert review of the assessment program.

The results of this contract will be used by AECB staff to determine whether the utility has demonstrated adequate capability to cope with major fires at the BPND.

Proponent	PRDB, SED
Technical Advisor/Evaluator	PRDB (T. Dunstan), SED (B. Finigan)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$10k	$0k	$0k	$10k

Earlier Directly-Related Contracts and Funding:

2.130.2 Self-Testing of Programmable Controllers & Microcomputers

It is proposed to initiate a two phase project to develop guidelines for the review of self-test systems in custom engineered programmable controllers and industrial microcomputers used in safety related and special safety control systems for CANDU nuclear power stations. The first part of the project would review the current and proposed equipment and similar off-the-shelf manufactured products, along with the particular electronic technologies applied to identify the possible hardware failure modes and to develop a description of the hardware faults to be detected by an adequate self-test system. The second part would describe, in detail, methods to detect the hardware faults identified in Phase I, would develop a comprehensive checklist and set of guidelines for self-tests that are dependent on the particular electronic technology used, and would, as an illustrative example, evaluate the systems from the first part using these guidelines.

The use of programmable controllers and industrial microcomputers is extensive in CANDU nuclear power stations both in new stations and for the retrofitting of older units. This technology involves a complex blend of real-time software and high performance microcircuit devices for which the reliability history is limited. Guidelines are required to allow AECB staff to evaluate the adequacy of the self-test systems with respect to fault detection and the contribution to overall reliability.

The results of this project would assist AECB staff in the assessment of the self-test methods used in the shutdown systems at Darlington Nuclear Generating Station and in the OH-180 Programmable Controllers used throughout Darlington's safety related control systems.

Proponent	SED
Technical Advisor/Evaluator	SED (B. Finigan, R. Taylor), PRDA (I. Lee)
Project Manager	D.E. Connelly
Review Panel	12
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$70k	$0k	$0k	$70k
Earlier Directly-Related Contracts and Funding:						
2.130.1	$0	$7000	$0			$7000

2.134.1 Estimating Software Reliability for Reactor Shutdown Systems

It is proposed to initiate a multi-phased project that would address the question of estimating the contribution of the software to the unavailability of the Darlington trip computer systems. The project would be carried out in the following parts: 1) determine whether it would be technically feasible to estimate, to an acceptable degree of confidence, the contribution of the software to the unavailability of the shutdown systems; 2) if feasible, estimate the unavailability contribution for Shutdown System 1; and 3) repeat part 2 for Shutdown System 2.

The current unavailability analyses for the Darlington Shutdown Systems do not include the software contributions. Experience with similar critical software systems in aerospace and telecommunication applications indicates that the software contributions to system unavailability could be significant.

The results of this study would assist AECB staff in evaluating the overall reliability of the Darlington Shutdown Systems.

Proponent	SED
Technical Advisor/Evaluator	SED (B. Finigan, T. Leung, R. Taylor)
Project Manager	D.E. Connelly
Review Panel	12
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$75k	$75k	$0k	$150k
Earlier Directly-Related Contracts and Funding:						
2.127.1	$31000	$0	$0			$31000
2.127.2	$57000	$0	$0			$57000

2.152.3 Tutorial Sessions for CATHENA Users

It is proposed to prepare a compendium of various CATHENA case studies for the most common accident simulations encountered in accident analyses. The compendium must be self-explanatory to enable an infrequent user to set up a case using the examples contained in the compendium. A series of seminars to a group of interested users, to provide hands-on experience in setting up CATHENA to run various reactor cases and a subsequent consulting service to the AECB users, would be part of the requirement of this contract.

There is a need to have an in-house computing capability for assessing the validity of licensee safety submissions in addition to the ability to analyze any potential accident scenarios which may impact on plant safety.

The service provided by this project will assist AECB staff in using the CATHENA code with higher efficiency and effectiveness, and will reduce the time spent by AECB staff in searching for information necessary to run a case.

Proponent	SED
Technical Advisor/Evaluator	SED (K. Amrud)
Project Manager	A. Omar
Review Panel	
Contractor	Atomic Energy of Canada Ltd. - WNRE
Principal Investigator	D. Richards
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$0k	$20k	$10k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

86.1.22	$16441	$0	$0		$16441
2.152.1	$30000	$0	$0		$30000
2.152.2	$0	$45000	$0		$45000
	$0	$0	$0		$0

2.152.4 Five-Channel-per-Pass CATHENA Code for Darlington NGS

It proposed to modify the input data package for the AECB version of the CATHENA code from the current single-channel per pass to a more detailed five-channel per pass. The input data will be set up in accordance with Darlington NGS design data although a more detailed representation of the reactor, particularly in the region where boiling is expected to occur, is envisaged for this version. In developing the five-channel-per-pass version, emphasis will be placed on two-phase separation phenomena, e.g., flow separation in the reactor headers with possible flow recirculation between the feeders via the headers (without going through the steam generator).

The information on which Darlington NGS safety submissions are based is produced by licensee codes such as SOPHT (and, in the future, TUF), which contain numerous physical models and assumptions. There is a need to have an independent AECB in-house computing capability to perform check runs of the models and assumptions as part of the AECB normal course of evaluating the licensee calculations.

The new version of CATHENA will be used by AECB staff to analyze various accident scenarios. These results will be compared with those produced by the licensee's computer codes.

Proponent	SED
Technical Advisor/Evaluator	SED (K. Amrud)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

86.1.22	$16441	$0	$0			$16441
2.152.1	$30000	$0	$0			$30000
2.152.2	$0	$45000	$0			$45000
2.152.3	$0	$0	$30000			$30000

2.157.2 Detailed Analysis of Severe Accident Consequences

It is proposed to perform detailed analysis of the direct and indirect health and socioeconomic effects of selected severe accidents at Pickering or Darlington nuclear generating stations. The work would deal with a specific severe accident that will be recommended in a screening study (project 2.157.1) being conducted for the AECB. The scope of the proposed detailed analysis would cover: a) estimation of fission product release from, and retention within, fuel, heat transport systems, moderator and containment; b) determination of dose levels for specific weather conditions, population density and distribution, and dose and time thresholds; and c) estimation of the direct and indirect, immediate and long-term, health and socioeconomic effects. The analytical methods and computer codes which would be used in the proposed study would be those which would have been recommended in project 2.157.1.

The cost of a severe accident is not only associated with the loss of generated power and health effects, but also includes costs related to liability, cleanup, litigation, transboundary contamination, and long-term health, social, economic and psychological effects. Two of the major costs of the Three Mile Island accident are related to the increase in the liability coverage (current proposal before the courts is at $750 million) and to the decrease in public acceptance of the nuclear energy option. As for the Chernobyl accident, the major costs are those related to the cleanup, the long-term health and psychological effects, and a global collective dose of 600,000 person-sieverts.

The knowledge which will be gained from this study would be useful to the AECB and the provincial and federal governments in developing advice and making decisions related to liability, siting policies and emergency plans for large power reactors.

Proponent	DAA, RPD, SSS
Technical Advisor/Evaluator	DAA (J.G. Waddington), RPD (M. Measures), SSS (A. Omar)
Project Manager	A. Omar
Review Panel	14
Contractor	
Principal Investigator	
Category	2

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$20k	$150k	$130k	$300k

Earlier Directly-Related Contracts and Funding:

2.157.1	$20000	$107276	$0			$127276
2.202.1	$0	$0	$65000			$65000

2.158.1 Evaluation of Software Functional Specification Review Techniques

It is proposed to apply a descriptive language or other automated technique to evaluate a software functional requirement specification, such as for the trip computer software for Shutdown System 1 of the Darlington Nuclear Generating Station. A possible technique might be to transform the functional specification document into a database of rules via a descriptive programming language such as LISP or Prolog. This database would be analyzed for such characteristics as precision, lack of ambiguity, consistency and completeness.

The majority of deficiencies in software are due to deficiencies in the functional specification. Currently the checking of functional specification is based primarily on informal inspection. However, the program design, coding, and testing all rely on a thorough functional specification. The Darlington Shutdown Systems rely on software so it is essential that the integrity of the trip computer functional specifications be established.

This study will introduce AECB staff to formal testing or checking techniques for reviewing software functional requirement specifications. The resulting representation of the SDS-1 trip computer functional specification may also be used to model the behaviour of the system for reactor safety analysis and to assess the effectiveness of licensee test data sets.

Proponent	SED
Technical Advisor/Evaluator	SED (C. Downie)
Project Manager	D.E. Connelly
Review Panel	12
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.162.2 Childhood Leukemia around Canadian Nuclear Facilities (Phase II)

It is proposed to fund the ongoing epidemiological study of leukemia among children born in the vicinity of Canadian nuclear facilities. In this phase of the study, the incidence of leukemia among children (5 to 14 years) born within a radius of about 25 kilometres of, or within the same county as, the nuclear facilities at Pickering, Bruce, Chalk River and Rolphton, Port Hope, and Elliot Lake, Ontario, will be compared with the corresponding incidence and mortality of childhood leukemia among Ontario children of this age group.

Since the results of the Phase I study were statistically inconclusive, the second phase of the study (Phase II, in which the investigation of childhood leukemia will be extended to children up to the age of 14 years) is being initiated. If, after Phase II, there is an indication of the existence of any statistically significant clustering, then a detailed study (Phase III) at these nuclear facilities in Canada will be proposed to examine the influence of radiation doses and any other factors, such as exposure to chemicals present in the environment, on the incidence of childhood leukemia.

It is anticipated that the results of this phase of the study will clarify whether any clustering of childhood leukemia exists in the vicinity of the nuclear facilities under investigation. (The amounts shown below are for the Phase II portion of the work.)

Proponent	RPD, ACRP
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	Ontario Cancer Treatment & Research Foundation
Principal Investigator	A. E. Clarke
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$0k	$69k	$15k	$0k	$0k	$84k
Earlier Directly-Related Contracts and Funding:						
2.162.1	$68000	$0	$0			$68000

2.175.1 Pump Cavitation and Piping Vibration (I)

It is proposed to conduct a multi-phase study to investigate pump cavitation and piping vibration, and their interrelationship. Phase I would review Ontario Hydro pump stability piping analyses, and perform a literature search on large amplitude piping vibrations. Also in Phase I the contractor would be asked to design a simplified small diameter pipe loop. This should take into account the predicted primary heat transport system piping vibration and main coolant pump two-phase flow characteristics. Phase II of the study would be to build and commission a test loop. The instrumentation should be sufficient to define the displacement of the test section, the flow characteristics of the fluid, and the overall energy balance. The test results would be analyzed and compared with the findings of Phase I.

Pump cavitation under voided conditions can cause severe pipe vibration. Calculations, based on forces measured directly on reactor main coolant pumps, predict that the vibration can be of such magnitude that failure of the pump supports or piping can occur. These calculations are complex and include numerous assumptions so that it is difficult to assess whether they are conservative or not.

The results of this study would be used by AECB staff to acquire information on the characteristics of cavitation-induced piping vibration and its relationship to the energy input to the pump. This information would then be used in the evaluation of piping stability analyses presented by licensees.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$35k	$150k	$50k	$235k

Earlier Directly-Related Contracts and Funding:

34-2-5-1	$16000	$0	$0			$16000
34-2-5-6	$12000	$0	$0			$12000

2.176.1 Software Functional Requirement Specification Techniques

It is proposed to identify and evaluate the suitability of techniques for the definition of software functional requirements for safety critical computer-based systems. This work would provide AECB staff with the latest information available concerning the preparation of software functional specification for safety critical applications of programmable controllers and microcomputers in nuclear generating stations.

The software functional requirement specification is the cornerstone upon which a software project is built. It is used in every phase of the project; structural design, coding, debugging, integration testing, and validation testing. Omissions or lack of clarity can result in software that does not function as desired. Studies have shown that this is the most common source of software failures.

The results of this study would be used to assess the effectiveness of methods used by licensees to specify safety critical software functional specifications for nuclear generating stations.

Proponent	SED
Technical Advisor/Evaluator	SED (R. Taylor)
Project Manager	D.E. Connelly
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.184.2 Ballooning of CANDU Pressure Tubes - Model Verification

It is proposed to conduct small-scale separate effects tests on irradiated and hydrided pressure tube (P/T) specimens to verify the hypotheses formed from Phase 1 of this project: a) that uniform hydriding has no effect on ballooning; and b) that irradiation and hydride blisters will affect ballooning. The influence of the ambient environment on P/T ballooning will also be assessed in these tests. Test results will be used to design integrated full-scale ballooning verification experiments using P/T sections with near-end-of-service-life material properties.

Safety analyses predicted that certain failures in reactor cooling systems could lead to coolant stagnation in fuel channels and to the ballooning and eventual rupture of pressure tubes. Current models of pressure tube ballooning behaviour are based on tests conducted with new pressure tube material in an inert environment, and may overestimate the ductility and creep behaviour of end-of-service-life P/Ts under actual conditions.

The results of this project would lead to an improved ability to predict the strain at failure of rapidly creeping pressure tubes by confirming or developing hypotheses about the effects of irradiation and deuteriding of zirconium alloys. This would permit improved assessments by AECB staff of predictions of pressure tube behaviour in accident situations.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	J. Pachner
Review Panel	15
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$100k	$300k	$400k	$800k
Earlier Directly-Related Contracts and Funding:						
2.184.1	$0	$35000	$0			$35000

2.191.1 Review of Piping System Failures at Discontinuities

It is proposed to conduct a review of industry experience with failures at junctions, elbows, attachments and other discontinuities in piping systems.

Recourse to 'leak-before-break' arguments in licensing submissions for CANDU reactor piping systems has necessitated assessment of evidence on the stability of through-wall cracks in pipes under similar service conditions. A considerable body of test data exists for failures in piping but most of these apply to uniform pipe sections and not to regions in the vicinity of discontinuities. The aim of this project is to address the deficiency by reviewing service experience of failures in piping systems with a particular focus on occurrences at junctions, elbows, attachments and other discontinuities.

The project results would contribute to the technical basis needed to support AECB assessments of 'leak-before-break' arguments.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (J.K. Pereira)
Project Manager	J. Pachner
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

2.195.1 Fracture Toughness of Fuel Sheath Material

It is proposed to perform fracture toughness tests on fuel sheath material samples to determine the effect of irradiation and hydriding. Tests are to be performed with both irradiated hydrided and fresh samples. The level of irradiation and hydriding would be representative of a typical CANDU fuel bundle.

There are many accident scenarios that can be postulated for CANDU reactors which involve spent fuel bundles impacting unyielding surfaces. Ontario Hydro has performed experiments with fresh fuel bundles in an attempt to determine the bundle disintegration pattern. It is unclear whether a spent fuel bundle would display strength characteristics similar to a fresh bundle.

Results from the proposed experiments will enable AECB staff to determine whether experiments that have been performed with unirradiated unhydrided fuel bundles are representative of spent fuel bundles. This will assist in resolving licensing issues which involve the mishandling of used fuel bundles and the ejection of bundles from a fuel channel.

Proponent	SED
Technical Advisor/Evaluator	SED (K.K. Amrud), CQAD (B. Jarman)
Project Manager	J. Pachner
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.196.1 Statistical Review of Pressure Tube Inspection Data

A project is proposed to study possible correlations between pressure tube deuterium measurements from In-Service Inspection (ISI) and tube metallurgical, manufacturing or operational factors. The contractor would obtain available data from pressure tube history dockets and other industry sources.

Deuterium pick-up is a potential life-limiting degradation of pressure tubes. A previous analysis by AECB staff of pressure tube deuterium contents indicates that some tubes are picking up deuterium at rates significantly faster than others; however, no correlation was evident with iron content, channel power, effective full power hours, core location or mass flow rate. It is therefore believed that the cause of the observed variation lies with other manufacturing or operational factors.

A valid predictive relationship between pressure tube manufacturing or operational variables and deuterium contents would enable ISI sampling to be focussed on "high risk" populations of tubes, giving a greater degree of conservatism over the existing, random sampling program.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (B. Jarman, I.M. Grant)
Project Manager	J. Pachner
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

2.199.1 The Prevention, Mitigation and Accommodation of Water Hammer

It is proposed to join the Water Hammer Prevention Project which is being undertaken by the Electric Power Research Institute (EPRI). A database for water hammer will be compiled using field and experimental data and subjected to root cause analysis; an engineering reference manual will be produced. Also, models and computer codes that deal with the issues will be reviewed. From plant experience, guidelines to prevent, diagnose and assess water hammer will be produced. The AECB and Ontario Hydro would jointly represent Canada's interests in the program. The AECB share would be via an in-kind contribution by performing high-pressure experiments in Canada and feeding the results into the database of the program.

In a previous AECB contract (Project 2.146.1) a critical review was conducted of information on loadings arising from injecting cold water into a two-phase system. Water hammer was recognized to be the main mechanism causing such loadings. One of the recommendations that came from this project was to consider joining the EPRI program, since it is the most comprehensive work currently being undertaken by a research organization. In addition, there is a need to obtain information on water hammer in high pressure, steam-water systems relevant to CANDU heat transport sytems.

The project will produce diagnostic tools with which AECB staff would be able to examine the cause and the consequences of events involving water hammer in single- and two-phase systems.

Proponent	CQAD, SSS
Technical Advisor/Evaluator	CQAD (J.K. Pereira), SSS (A. Omar)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$0k	$20k	$70k	$0k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

2.146.1	$23430	$0	$0			$23430

2.200.1 A Safety Course for Pressure-Tube Type Reactors

It is proposed to develop an annual course which would provide a suitable forum for exposing AECB staff and other national and international nuclear industry personnel to the most recent developments in safety analysis, operation and regulation of pressure-tube type reactors. The proposed project would involve design, development and initial implementation of such a course. The course would be given by experts drawn from the nuclear industry and academic institutions and could be prepared and presented in conjunction with them.

Currently in Canada, there does not exist an appropriate and formally structured program which provides an opportunity for staff of the AECB and Canadian and foreign utilities to focus on current trends in safety analysis, operation and regulation of pressure-tube type reactors.

A custom-made course for participants interested in pressure-tube type reactors would be more effective than similar courses on light water reactors. The course would be used to upgrade the skills of the attendees by providing state-of-the-art information on a wide range of topics related to the design, safety analysis and regulatory aspects of pressure-tube type reactors. The course would also serve to introduce new personnel into the realm of nuclear safety analysis and evaluation.

Proponent	OCD, SSS
Technical Advisor/Evaluator	OCD (J.G. Waddington), SSS (A. Omar)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.202.1 Severe Accident Source Term

It is proposed to develop a software package suitable for desktop computers to estimate the order-of-magnitude value of source terms within containment. The software would have the capability to estimate fission product species and their concentrations in grains, grain boundaries, free inventory, heat transport systems, and containment. The software would have flexible input suitable for introducing accident conditions as well as the conditions within the containment.

In a current project (Project 2.157.1) being conducted for the AECB, a methodology is being developed and used to provide order-of-magnitude estimates of the source term for a severe accident. It would be extremely useful if this methodology were put in a user-friendly software package which could be used by AECB staff to obtain an indication of the behaviour of fission products after an accident.

The software which would be the product of this project would be used by AECB staff in performing sensitivity studies of various factors influencing the prediction of fission product concentrations in an accident. A potential subsequent project would be to develop software to estimate the fission products released from the containment. These estimates could be fed to a dispersion software package (e.g., ALOHA) to estimate the dose after a specific scenario. Ultimately, this suite of software would be used as input to the estimation of the health and socio-economic effects of an accident, and in plans for emergency preparedness.

Proponent	SSS, SED
Technical Advisor/Evaluator	SSS (A. Omar), SED (V.Q. Tang, L. Truong)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	2

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$65k	$0k	$0k	$65k

Earlier Directly-Related Contracts and Funding:

2.157.1	$20000	$107276	$0			$127276

2.203.1 Intermediate and Full Scale Tests on Hydrogen Burn Phenomena

It is proposed to enter into a cooperative progam with KfK and Battelle (Europe) to investigate hydrogen behaviour in containment. The proposed program would include performing experiments in intermediate and full scale, multi-compartment facilities to investigate the effect on hydrogen combustion of equipment size, gaseous mixture composition, multi-compartment configuration and the effects of the presence of steam. In addition, the effect of hydrogen combustion on the redistribution of aerosols and the effectiveness of the catalytic ignitor/recombination unit will also be studied.

Current licensee submissions are based on results produced from small-scale and special effects experiments. There is no information on hydrogen combustion behaviour in a large-scale multi-compartment arrangement similar to those normally found in the containment of a nuclear power reactor. Furthermore, information on the scaling laws, flame acceleration due to obstacles, and combustion in interacting jets is also very limited. In a previous study conducted for the AECB (Project 2.138.1) it was recognized that key assumptions related to hydrogen mixing and burning rate could not be justified. In addition to conducting in-situ tests to determine the hydrogen distribution in the Darlington NGS containment, research in some of the above areas was also recommended.

The results of this project would be used to assess the assumptions in licensee submissions. The knowledge gained in this project would also provide AECB staff with insight into the combustion phenomena and some basis for assessing the effectiveness, claimed by licensees, of the mitigation of the consequences of a hydrogen burn.

Proponent	SED
Technical Advisor/Evaluator	SED (J.K. Khosla)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$60k	$60k	$60k	$180k
Earlier Directly-Related Contracts and Funding:						
2.138.1	$48600	$0	$0			$48600

2.204.1 Pressure Tube Rupture In A Closed Tank - Thermalhydraulic Loadings

It is proposed to reactivate a project (which was proposed in FY 1984/85 but postponed) to investigate the consequences of pressure tube failure on in-core components. The proposal for Phase I deals with the construction and then the use of a test facility to characterize, in a series of separate-effect tests, the thermalhydraulic loadings within a closed tank due to a single fuel channel rupture at operating conditions.

The original proposal of 1984/85 was postponed due to the initiation at that time of a Japanese program addressing the characteristics of pressure tube rupture in a closed tank in which the test facility was vertical. On the basis of recent information currently obtained, AECB staff believes that because of differences in geometry and operating conditions the Japanese tests are not relevant to the issues raised by AECB staff in BMD 85-158. Based on current calculations and experimental results, AECB staff are satisfied that the calandria shell is not at risk; but are not fully satisfied that the consequences on the in-core safety-related components would not hinder the safe shut-down of the reactor. The reasons for this position are given in BMD 85-158.

The findings of this phase of the program will provide information on the degree and extent of the thermalhydraulic loadings within the closed tank.

Proponent	SED, CQAD, SSS
Technical Advisor/Evaluator	SED (C.W. Snoek, J. Tong), CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$150k	$400k	$200k	$750k
Earlier Directly-Related Contracts and Funding:						
84.1.10	$82140	$0	$0			$82140

2.205.1 Training Requirements for Authorized Operating Personnel

It is proposed to conduct a review of utility and AECB training requirements of authorized operating personnel at CANDU nuclear power plants. The work would be done in three phases. The first phase would consist of a review of the relevant information currently available to the AECB. The second phase would involve reviewing the training currently being delivered at the utilities in relation to the documented requirements. The final phase would involve comparisons and evaluation of the collected information and would include recommendations for appropriate regulatory training requirements.

The AECB is presently considering extending the current operator authorization process so that periodic re-authorization could be mandatory for continuation in the authorized position. For this purpose, we are assessing the training requirements of the authorized staff to achieve and maintain required levels of competence.

The proposed work would provide information for developing appropriate regulatory training requirements in the authorized positions.

Proponent	OCD
Technical Advisor/Evaluator	
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

2.206.1 Methodology for Assessment of Training Programs

It is proposed to document methods and techniques which can be used in performing a systematic assessment of the quality and effectiveness of training programs for nuclear plant personnel. The proposed work would involve a survey of programs used for quality control of training in those industries which have an impact on public safety. It would also include a review and evaluation of the findings and specific recommendations for an effective assessment tool for AECB use.

The current AECB audit program is intended to confirm the adequacy of training received by the operating personnel through a formal examination process. To extend this process and ultimately to reduce reliance on examinations, AECB staff are planning to conduct periodic assessments of the quality and effectiveness of the utilities' training programs.

The proposed work would provide guidelines to the AECB staff for conducting assessments of the quality and effectiveness of the utilities' training programs.

Proponent	OCD
Technical Advisor/Evaluator	
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$100k	$0k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

2.207.1 Guidelines for Examination Time Allocation

It is proposed to develop guidelines for allocating appropriate times for the answering of questions in the AECB examinations for control room operators and shift supervisors. The proposed work would include a survey of related practices in other similar professions, an analysis of the data collected and the development of guidelines.

AECB examinations for authorized personnel are required to be completed within a specific time. For the sake of exam validity, it is important to ensure that the candidates have an appropriate amount of time to complete the exams within the specified limit.

The proposed work would provide guidelines for AECB staff in the preparation of written examinations.

Proponent	OCD
Technical Advisor/Evaluator	OCD (G. Turcotte)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

2.209.1 Pickering Seismic Safety Margin (Feasibility Study)

It is proposed to study the safety margins in the seismic design of the Pickering Nuclear Generating Station. The study would focus on the whole plant response to seismic ground motion (earthquake) in excess of the design basis seismic ground motion. The Pickering NGS would be selected because the "A" station is the oldest operating plant in Canada and was designed to lower seismic standards than modern stations. The population around the Pickering site is also the highest of any nuclear generating station in Canada.

The study is proposed because there are, in the nuclear safety context, large uncertainties in the estimates of seismic hazard in eastern Canada. Some recent work in Canada and the U.S.A. suggests that the seismic hazard may have been underestimated in the past for nuclear power plant sites. On the other hand, experience from real earthquakes suggests that modern structures and equipment may well be able to withstand vibratory ground motion substantially in excess of that for which they are designed. The most vulnerable equipment may be electro-mechanical items such as rotating machinery, motorized valves, and electrical equipment whose function may be disabled by an earthquake. Since an earthquake affects all parts of a station simultaneously, a comprehensive study would be needed to determine the severity of ground motion that would likely cause damage that would pose a radiological danger to persons in the vicinity of the nuclear station. The first phase would be a feasibility study to determine the approach to be adopted and the cost of the full study.

The results of this study, together with the results of other studies aimed at reassessing the seismic hazard in the Pickering-Darlington region would give the AECB a basis for setting seismic safety criteria and making regulatory decisions regarding these and other nuclear power reactors.

Proponent	SSS
Technical Advisor/Evaluator	SED (K. Asmis)
Project Manager	J. Pachner
Review Panel	21
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.210.1 Participation in the USNRC Severe Accident Research Program

It is proposed to participate with Atomic Energy of Canada Limited - Research Company (AECL-RC) in the United States Nuclear Regulatory Commission (USNRC) Severe Accident Research Program (SARP); the estimated cost of the SARP is $14.5 million U.S. AECL-RC is a partner in the USNRC SARP, via an agreement which is in effect until October 1991, at a cost of $600k U.S. per year. It is proposed that the AECB contribute $150k U.S. over three fiscal years to AECL-RC in exchange for a full share in the described rights and deliverables available from the program.

The USNRC SARP is a comprehensive research program designed to resolve issues related to severe accidents such as, in the near-term, containment performance, and in the long-term, phenomena exhibited by severe accidents and methods for assessing fission products behaviour. The information generated from this program will provide a pool of knowledge from which the AECB would extract relevant work and use it as is, or after being modified, for CANDU applications.

The information which would be gained from this project would be used by AECB staff in the performance of projects related to severe accidents assessment.

Proponent	DAA, SSS
Technical Advisor/Evaluator	DAA (J.G. Waddington), SSS (A. Omar)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$58k	$58k	$58k	$0k	$174k

Earlier Directly-Related Contracts and Funding:

2.211.1 Tritium Surface Contact Dosimetry

It is proposed to measure the uptake of tritium by mammals (rats, pigs, and humans) following contact of skin with surfaces which are contaminated with elemental tritium (HT), and to study quantitatively the subsequent distribution of organically-bound tritium (OBT) and oxidized HT (HTO) in body tissues and fluids. It is proposed that different aspects of the work will be carried out in Canada and in the United States. The AECB will be a member of a management group responsible for directing the work. Two external review groups, one of technical experts and the other concerned with ethical aspects, will be constituted to advise the management team.

An unknown fraction of the total dose from tritium arises from contact with surfaces contaminated with tritium. The only human data on tritium uptake from contact with surfaces contaminated with elemental tritium have been acquired from a few experiments that followed four volunteers in 1965. More recently, work at CRNL has been done with rats, using HT-contaminated planchettes. The present study is proposed because the earlier work on exposures of humans and rats, via contact with tritium-contaminated surfaces, has produced as-yet unexplained and sometimes dissimilar findings. These findings call into question the accuracy of currently-used calculational techniques for evaluating the dose to nuclear power reactor workers, and others, who are occupationally exposed to tritium via contact with surfaces contaminated with tritium (e.g., among workers at tritium removal facilities and tritium lighting manufacturers, and among university researchers).

It is anticipated that the findings of this project will enable AECB staff and licensees to evaluate more accurately the dose and its distribution within the bodies of workers who are subject to exposure to tritium-contaminated surfaces. (The work is proposed to be cost-shared among Ontario Hydro, Canadian Fusion Fuels Technology Program (CFFTP), Atomic Energy of Canada Ltd., AECB and the U.S. National Fusion Safety Program. Ontario Hydro has proposed to fund more than 50% of the cost of the total project, the upper estimate of which is likely to be $500k. The estimated AECB funding, presented below, is based on this upper estimate.)

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	20
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$50k	$50k	$150k

Earlier Directly-Related Contracts and Funding:

2.212.1 Analysis of Voice Communications

It is proposed to fund a contract which will record and subsequently analyze voice communications in the main control room of a major nuclear power plant to identify sources, communication patterns, content, frequency and urgency, in both normal operation and simulated emergencies.

Voice communication is an essential but unplanned and unrecorded flow of information in the main control room. An understanding of the use of voice messages will improve the knowledge base on staff functioning in the main control room.

The results of this study are required for input into the safety analyses of proposals to computerize some functions which are currently performed by main control room staff.

Proponent	SED
Technical Advisor/Evaluator	SED (L. Innes)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

2.214.1 Review of Supervisory Functions in Nuclear Power Plants

It is proposed to fund a contract which would perform an assessment of the supervisory function in NPPs. Specific reference would be made to training for supervision, the practice of supervisory roles, and the criteria for supervisor performance assessment. The scope of the work would cover first-line supervisors in operations and in maintenance.

One of the critical components in a program to ensure consistent high quality performance in the workplace is good supervision of the correct type. Consistent occurrence of problems associated with human error may have a source in the style or quality of supervision.

The development of regulatory stances on matters related to human performance in NPPs can only progress adequately when an improved insight into workplace dynamics is achieved. The results of the contract would provide information on the dynamics of the supervisory function.

Proponent	SED
Technical Advisor/Evaluator	SED (L. Innes)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

2.215.1 Criticality Energy Release Rate in Uranium Solutions

It is proposed to fund a contract which would investigate and study the criticality phenomenon in solutions (suspensions). The study would focus on energy release rate if criticality occurred inadvertently.

The AECB has become concerned about the risks posed by the "FISSTANK" facility at Chalk River Nuclear Laboratories (CRNL). This tank is used to collect very high level wastes derived from the production of molybdenum-99 using 93% enriched 'target' fuel irradiated in the NRU and NRX reactors. Included with this waste solution (dissolved in nitric acid) is a significant quantity of uranium-235 whose concentration has to be maintained below limiting values. If these limits were to be inadvertently exceeded a criticality (rapid power excursion) would occur and a significant amount of energy would be released. The ability of the tank to contain this potential explosion depends to a great extent on the process whereby the heat release creates voids (steam bubbles) whose negative reactivity could terminate the excursion. The AECB anticipates that a major safety assessment effort will be needed by CRNL to justify the integrity of the tank under such circumstances, and, therefore, requires an independent opinion to advise the AECB on the adequacy of CRNL's assumptions.

It is anticipated that CRNL will attempt to justify a new tank on the same basis as before. The information generated by this contract will supply the AECB staff with independent knowledge in preparation to evaluate the safety of the new tank design.

Proponent	SED
Technical Advisor/Evaluator	SED (C. Downie)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

2.216.1 Validation of Positive Void Effect

It is proposed to fund a contract which would examine the positive void reactivity effect in CANDU reactors. The study would include a detailed and critical literature search and review of the experimental and theoretical justification for the currently-used values of the void reactivity of the primary heat transport system.

Simulations of reactor power pulses under distorted flux conditions have indicated a proximity to prompt criticality. The AECB, therefore, requires to confirm present estimates of the positive void coefficient. In response to the AECB's requirements (Chernobyl Report), Ontario Hydro has conducted an investigation of the effects of distorted flux/power shapes on shut off rod (SOR) effectiveness. In Pickering A, the distorted shapes arising from low moderator levels sufficiently reduce the effectiveness of the SORs to the extent that prompt criticality is predicted to occur. It is, therefore, important to obtain an upper-bound estimate of the void reactivity resulting from a complete blowdown of a CANDU reactor.

The results of the contract would provide information which will be used in the safety analyses regarding the potential of prompt criticality to occur in power reactors in some postulated accidents.

Proponent	SED
Technical Advisor/Evaluator	SED (C. Downie)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

2.217.1 Seismic Monitoring East and North of Toronto

It is proposed to establish at least three seismograph stations, each of which is to house a three-component digital seismograph, in order to undertake seismic monitoring in the western Lake Ontario-Lake Simcoe-Georgian Bay area. This area was chosen because of the existence, there, of the Pickering and Darlington Nuclear Generating Stations. This proposed project was endorsed by MAGNEC on October 4, 1989.

This study is proposed in order to locate, as precisely as possible, microseismic events and ultimately to determine whether or not there is a spatial relationship between earthquakes, irrespective of size, and variously expressed lineaments in the aforementioned area.

It is anticipated that the results of this study will bear directly on improving seismic hazard estimates because reliable locations of microseismic events will aid geoscientists in determining whether or not there are active faults in the vicinity of the generating stations at Darlington and Pickering. If it is shown that there are active faults, then seismologists will be able to effect calculations of seismic wave attentuations from particular locations rather than assuming random sources.

Proponent	SSS
Technical Advisor/Evaluator	DRR (Z. Domaratzki), SSS (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	22
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$128k	$55k	$55k	$238k

Earlier Directly-Related Contracts and Funding:

3. OTHER FUEL CYCLE FACILITIES, GENERAL

3.101.2 Demonstration of the Feasibility of Directly Dating Quartz (2)

It is proposed to obtain samples of rock, the ages of which lie for the most part within the range of from about 400 million years to 1,000 million years, and date them using the electron spin resonance dating technique developed in Phase 1.

This study is proposed in order to establish conclusively that a linear relationship exists between the strength of the ESR signal and the age of the quartz. This apparent relationship was discovered in the previous study by evaluating samples in the age ranges of from 100 thousand to 400 million years and from 1 billion to 1.4 billion years. However, there is a 600 million-year data gap between those two groupings and this has to be filled in order to confirm or deny the relationship.

It is anticipated that the results of this study, if they establish that the linear relationship exists, will eventually be useful for determining the age of last movements along faults. This will, in turn, provide a means for determining whether or not an area is tectonically stable which, of course, has implications for seismic hazard and seismic risk estimates relevant to nuclear facilities.

Proponent	SSS
Technical Advisor/Evaluator	SSS (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	16
Contractor	
Principal Investigator	
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$0k	$5k	$25k	$30k	$0k	$60k
Earlier Directly-Related Contracts and Funding:						
3.101.1	$50000	$0	$0			$50000

3.106.3 Transfer of Radionuclides to Human Milk - Phase 3 Pilot Study

It is proposed to conduct a small-scale sampling and analytical program to determine the concentration factors for certain radionuclides in the uranium and thorium decay chains in the pathway from food to human milk. In a recently completed feasibility study (INFO 0192-2) adequate techniques for determining the very low levels of these radionuclides found in human milk samples were developed. A detailed plan for a full-scale sampling program was also recommended in the report.

A literature survey conducted for the AECB (INFO 0192) showed that little information existed on the transfer of radionuclides via the human milk pathway. As part of an ongoing review, the AECB has therefore decided to conduct research to determine whether this is a significant pathway in contributing radiation dose to breast-fed infants.

It is anticipated that the results of the study will enable the AECB to determine the importance of human milk as a component in radionuclide transfer and, consequently, its significance in the derivation of release limits for nuclear facilities, such as uranium mines and mills.

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Letourneau)
Project Manager	R. Avadhanula
Review Panel	11
Contractor	Monenco Consultants Limited
Principal Investigator	J. Dean
Category	1*

Past	89/90	90/91	91/92	Future	Total
$10k	$55k	$35k	$0k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

84.4.17	$30000	$0	$0		$30000
86.4.9	$40000	$0	$0		$40000

3.111.1 Evaluation of Data and Models on Uranium Metabolism - Europe

It is proposed to continue to fund the compilation of currently known data regarding the intake, transfer (among organs), retention, and excretion rates of uranium in uranium workers, with a view to: testing currently available metabolic and dosimetric models with different data sets; comparing computed excretion patterns to the observed ones; and determining which model describes best the known data (or how a selected model should be modified to fit the observed data).

Several models for uranium metabolism exist at present, but none seems to describe realistically uranium transfer, retention, and excretion rates in humans. Since individual doses from occupational uranium intake are generally determined from the interpretation of bioassay data (urinalysis), the AECB Radiation Protection Division needs to identify and acquire a reliable tool for calculating doses in the case of exposure to uranium compounds.

It is anticipated that the study will assist in identifying and in providing AECB staff with the state-of-the-art metabolic and dosimetric model for uranium intake.

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	P. Duport
Review Panel	4
Contractor	Centre d'Études Nucléaires de Fontenay-aux-Roses
Principal Investigator	P.G. Beau
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$15k	$21k	$0k	$0k	$36k

Earlier Directly-Related Contracts and Funding:

3.111.2 Evaluation of Data and Models on Uranium Metabolism - North America

It is proposed to continue to fund the compilation of currently known data regarding the intake, transfer (among organs), retention, and excretion rates of uranium in uranium workers, with a view to: testing currently available metabolic and dosimetric models with different data sets; comparing computed excretion patterns to the observed ones; and determining which model describes best the known data (or how a selected model should be modified to fit the observed data).

Several models for uranium metabolism exist at present, but none seems to describe realistically uranium transfer, retention, and excretion rates in humans. Since individual doses from occupational uranium intake are generally determined from the interpretation of bioassay data (urinalysis), the AECB Radiation Protection Division needs to identify and acquire a reliable tool for calculating doses in the case of exposure to uranium compounds.

It is anticipated that the study will assist in identifying and in providing AECB staff with the state-of-the-art metabolic and dosimetric models for uranium intake.

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	P. Duport
Review Panel	4
Contractor	
Principal Investigator	
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$5k	$40k	$35k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

3.123.1 Influence of Macrophages on Dissolution of Uranium Compounds

It is proposed to study, in the laboratory, the influence of macrophages, oxygen and carbon dioxide on the in vitro dissolution rates of uranium compounds, as a function of the chemical forms and particle sizes of these compounds. (Macrophages are specialized cells whose function is to destroy bacteria and foreign materials that enter an organism.) The results of the in vitro solubility tests will be compared to clearance rates of the same uranium compounds deposited in the tracheal lobe of the respiratory system of sheep.

Experimental data on the biokinetics of uranium in man are not consistently compatible with in vitro solubility rates (of the same compounds) which are widely used in current dosimetric models. Recent information from laboratories of the French Atomic Energy Commission (Service of Experimental Pathology) indicates that the solubility rate of uranium compounds is significantly enhanced by the presence of macrophages in, and by the addition of oxygen to, simulated lung fluid. The solubility rates observed under these experimental conditions seem to represent more accurately the clearance rates observed in man. The solubility rate of radioactive material is an important parameter of metabolic and dosimetric models, and it is necessary that AECB staff know, and use, the most realistic and accurate parameters in these models, whether for determining regulatory exposure limits or for deriving bioassay guidelines for accidental or routine radiation exposures. The proposed study would be designed on the basis of the procedures developed and tested by the French Atomic Energy Commission and on the use of sheep as an experimental animal. It has been shown that the respiratory tract of sheep, with its tracheal lobe that branches directly from the trachea, lends itself to localized deposition of test materials without impairing significantly respiratory functions. However, these procedures would be used in parallel with procedures developed in previous AECB studies, with a view to correlating data of past and future solubility tests.

It is anticipated that the results of the study will provide the AECB with realistic solubility parameters to be used for the determination of bioassay guidelines, and for exposure and dose calculations. It is also anticipated that the results will be used to develop a laboratory procedure to determine, accurately and economically, solubility rates and lung clearance rates of uranium compounds.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	P. Duport
Review Panel	5
Contractor	University of Sherbrooke
Principal Investigator	R. Bégin
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$10k	$60k	$60k	$10k	$140k

Earlier Directly-Related Contracts and Funding:

3.124.1 Assessment of Errors in Airflow Measuring Instruments (U Mines)

It is proposed to determine theoretically and experimentally (in the laboratory) the errors and uncertainties associated with the measurement of airflow rate in air monitoring instruments with a view to evaluating the contributions of these errors to the overall uncertainties attached to the measurements of airborne radioactivity.

Current methods used to determine the concentration of airborne radioactive materials are based on the use of fixed or portable instruments that draw a volume of air through a filter. The air concentration of radioactive material is calculated from the activity collected on the filter and from the total volume of air drawn through the filter. Since sampling apparatus is generally not equipped with a time integrating meter, the volume of air sampled is derived from a short-time airflow rate measurement. Airflow rates are measured with a variety of instruments that are based on different principles (bubble tube, rotameter, mass flow meter, wet test meter, hot-wire flow meter) and respond differently to changes in pressure and temperature. Sometimes, sampling equipment is tested in the laboratory, under pressure and temperature conditions different from those encountered in the field. Some pumps produce a pulsated flow that may affect the response of certain types of flow meters. All the above affect the reliability and comparability of airflow measurements which are made to calibrate sampling systems. Although the determination of uncertainties and errors in radiation counting have been thoroughly documented, the contribution of errors and uncertainties attached to airflow measurements has never been studied in the context of air monitoring for radiation protection purposes. The knowledge of these errors is necessary to evaluate the accuracy and reliablity of "air quality" data collected in mines, mills, and other facilities in which airborne radioactivity is a hazard.

It is anticipated that the study will identify the sources of error and the magnitude of the uncertainties attached to airflow rate measurements that are used together with radiation counting to measure the activity concentration of radionuclides in air. The study will therefore allow AECB staff to compare and assess the reliability and accuracy of monitoring data provided to the AECB, by its licensees, as evidence of compliance with the relevant licences and regulations.

Proponent	UFD, HES
Technical Advisor/Evaluator	UFD (J. Hore)
Project Manager	P. Duport
Review Panel	
Contractor	CANMET Elliot Lake Laboratory
Principal Investigator	J. Bigu
Category	1*

Past	89/90	90/91	91/92	Future	Total
$15k	$25k	$1k	$0k	$0k	$41k

Earlier Directly-Related Contracts and Funding:

3.125.1 Study of Chemical Toxicity of Uranium Hexafluoride

It is proposed to investigate the chemically toxic effects, in humans, from accidental acute releases of uranium hexafluoride in uranium conversion plants.

The chemical toxicity of uranium and fluorine are known individually. However, during an accidental release of uranium hexafluoride in a conversion plant, it is probable that an acute uptake of uranium by workers will be associated with an acute uptake of the fluoride. The tests to determine if a worker may have suffered damage to his organs are based primarily on the results of uranium excretion patterns and kidney function assessments. This work is proposed because it appears that there is insufficient information available on the toxic effects due to the combination of uranium and fluorine in the compound uranium hexafluoride.

It is anticipated that the proposed research will provide information on the health effects of uranium hexafluoride on humans from accidental acute releases in conversion plants. The gathered information may also be used in the development of action level guidelines concerning the return of acutely-exposed workers to their normal duties. (This project will begin with a literature review; if insufficient information is found, then an animal study will be considered to gather the required information. The costs below reflect the estimated cost for a literature review only.)

Proponent	UFD, RPD
Technical Advisor/Evaluator	UFD (A. Ghosh), RPD (M. Measures)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

3.133.1 Carbon-14 in Food and in Excretions

It is proposed to measure the amount of carbon and the specific activity of radioactive carbon (C-14) in the daily intake of food and in the daily excretions of urine and stool obtained from healthy persons.

At present, the daily excretion rate of C-14 due to occupational exposure to radioactive carbon dioxide and to particulates containing C-14 is calculated by measuring the specific activity (C-14 per gram of stable carbon) in an aliquot of urine or stool, and by adjusting for the total stable carbon output in a 24-hour excretory sample. The amount of stable carbon excreted in a daily sample cannot usually be measured, and it is assumed to be equal to that given for Reference Man in ICRP 23. Additionally, an accurate dose estimation due to an uptake of C-14 requires a knowledge of the relative fraction of ingested C-14, which is eventually excreted in both urine and stool samples. There appears to be significant uncertainty in the values for Reference Man given in ICRP 23. It is therefore important to measure these parameters to enable an accurate dose estimation for exposure to C-14 in occupational situations.

The results of this study will improve dose estimates for exposure to C-14 among workers at nuclear facilities and among radioisotope users where C-14 is present.

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	R. Avadhanula
Review Panel	
Contractor	Atomic Energy of Canada Ltd. - CRNL
Principal Investigator	
Category	1*

Past	89/90	90/91	91/92	Future	Total
$10k	$45k	$15k	$0k	$0k	$70k

Earlier Directly-Related Contracts and Funding:

3.134.1 RBE from a Microdosimetric Approach

It is proposed to conduct a critical review on the state-of-the-art of the relationship between radiation-matter interactions in cell components and the Relative Biological Effectiveness (RBE) of high linear energy transfer radiation with an emphasis on the effect of alpha radiation on the cells of human bronchial epithelium.

In spite of elaborate laboratory experiments and epidemiological studies, risk coefficients for specific types of radiation are determined with uncertainties, at best, of the same magnitude as the variable being determined; in some cases, uncertainties are as large as one order of magnitude. An important parameter in establishing risk coefficients is the RBE of the type of radiation under consideration. Microdosimetry has been a powerful tool in the study of radiation-matter interaction in living cells, and of the changes induced in cell components at the molecular level. The continuous refinement of microdosimetric models has led progressively to a better understanding of radiation effects in the case of radionuclides incorporated in cell components, as well as that of exposure to external radiation. It seems, at present, that convergent efforts in epidemiology, animal experiments and microdosimetry are necessary to determine the RBE, and therefore the risk, more accurately. At a time when regulatory limits on exposure to radon daughters tend to be revised downward, it is important to understand, as well as possible, the mechanisms that lead from irradiation of lung tissues by alpha particles to malignancies in order to support regulatory decisions.

It is anticipated that a critical review of the state-of-the-art research on the relationship between radiation-matter interaction and biological modification at the nucleus, chromosome, or gene levels in the cell will provide necessary information to AECB staff in this domain and will strengthen the scientific bases upon which regulatory decisions are made.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

3.135.1 Measurement of Tritium in Canadian Food Items

It is proposed to develop and validate techniques of tritium measurement and to conduct analyses and measurements of organically bound tritium (OBT) in Canadian food items, particularly those produced in the vicinity of tritium-emitting facilities.

Tritium is a relatively important radionuclide that is released through atmospheric and aquatic pathways from CANDU nuclear generating stations (NGSs) and from other facilities and licensed activities. These releases are limited by the AECB through the setting of derived release limits which are calculated values based on the dose limit for members of the public. Reports of elevated levels of OBT relative to aqueous tritium (HTO) in food items and in human tissue have raised concern about the effect of such conditions on the validity of dose estimates based on the assumption that all tritium intake is rapidly dispersed throughout the body water and may be monitored adequately by urinalysis. The results of a critical review of the available literature presented in a recent AECB report, "The Assessment of the Significance of Organically-Bound Tritium in Environmental Materials" (INFO 0283), indicate that the specific activity of OBT was higher (in the range of 1 to 4) than that of HTO in most food items studied. The report also identified that adequate data on Canadian diet items are lacking and, further, that the meagre data, particularly on meat, as reported in the open literature are uncorroborated.

The results of this project will provide information to AECB staff on the significance of the OBT contribution to tritium dose and, as well, greater confidence in regard to the derived release limits for tritium from Canadian NGSs and from other tritium-emitting facilities.

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Létourneau)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$0k	$30k	$55k	$0k	$0k	$85k
Earlier Directly-Related Contracts and Funding:						
2.156.1	$11000	$0	$0			$11000

3.139.1 Offset River Terraces in the Charlevoix Seismic Zone

It is proposed to determine the elevations of, identify layered units and measure bedding attitudes within, terraces on each side of a lineament near Baie St. Paul, Quebec, in the Charlevoix Seismic Zone. Furthermore, it is proposed to attempt to correlate layered units on one side of the lineament with those on the other side. This project has been endorsed by MAGNEC.

This study is proposed in order to determine whether or not the terrraces are displaced and, if so, by how much. Displacement could indicate the presence of a tectonically active fault, and possibly a seismic source, within the Charlevoix Seismic Zone.

It is anticipated that the results of this study will be useful in identifying an active fault in a known seismic area and thereby establishing a criterion for recognizing potentially active faults in areas of critical structures.

Proponent	SSS
Technical Advisor/Evaluator	DRR (Z. Domaratzki), SSS (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	Laval University
Principal Investigator	J-Y Chagnon
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$0k	$10k	$20k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

3.102.1	$0	$0	$0			$0

3.144.2 Liquefaction Features in the Chicoutimi Area

It is proposed to excavate additional trenches in unconsolidated sediments in the Ferland-Boileau Valley near Chicoutimi for further documentation of liquefaction features produced by the November 1988 Saguenay earthquake. It is also proposed to continue the search for evidence of seismicity which may have occurred in that area prior to the recording of historical earthquakes (paleoseismicity). This project has been endorsed by MAGNEC.

This work is proposed because detailed documentation and evaluation of sand boils, begun during the summer of 1988, was completed for only two or three such features. There is a need to document as many liquefaction features as possible, irrespective of their manifestation, in order to determine whether or not a particular pattern or set of characteristics emerges and ultimately to establish, if possible, a well-founded set of criteria for recognizing evidence of paleoseismicity.

It is anticipated that the results of this study will provide the means for establishing criteria to recognize the effects of previous earthquakes and will also possibly aid in extending our knowledge of the seismic record in part of eastern Canada further back in time than historic seismic records allow. Should the anticipated results be realized, the AECB will be in a clear, defensible and unequivocal position to require licensees of existing, or applicants for future, nuclear facilities to conduct paleoseismic studies, particularly in areas which are not known to have experienced earthquake activity in historical time.

Proponent	SSS
Technical Advisor/Evaluator	DRR (Z. Domaratzki), SSS (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$20k	$37k	$0k	$57k
Earlier Directly-Related Contracts and Funding:						
3.144.1	$13000	$0	$0			$13000

3.148.1 Thorium Metabolism and Dosimetry - Literature Review

It is proposed to summarize and review, critically, the literature on intake, retention, excretion and health effects of thorium, with an emphasis on dose-effect (or intake-effect) relationships. The case of in vitro methods for predicting the biokinetics of thorium in man will also be examined.

Thorium is a bone-seeking element for which Annual Limits on Intake are very low. Thorium, in the form of natural Th-232 and in the form of its isotopes present in the uranium and thorium decay series, is present at all stages of the front end of the nuclear fuel cycle. Thorium has a number of industrial applications that can lead to the irradiation of workers where it is used. Consequently, a large number of persons among workers of the nuclear fuel cycle, non-nuclear industries, and members of the public are potentially exposed to intakes of thorium compounds. The AECB requires updated information on the behaviour of thorium in the human organism and on the associated human health effects, as well as on in vitro methods used to determine the solubility and transferability of thorium in man.

It is anticipated that the study will provide the AECB with the information necessary to evaluate the health hazards presented by thorium, to determine appropriate regulatory limits on intake, and to provide guidelines for monitoring exposures to thorium.

Proponent	WMD, RPD
Technical Advisor/Evaluator	WMD, RPD (F. Horvath)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$15k	$10k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

3.150.1 Different Biological End-Points to Study Radiation Effects

It is proposed to conduct a field and laboratory study of the effects of low-level chronic radiation exposure on different biological end-points in a selected species (e.g. growth, extinction, breeding, survival of newborns).

Results of several studies have raised concerns among national and international groups as to whether populations of organisms other than humans are indeed adequately protected at the level of exposure to radiation considered adequate for members of the public. A thorough understanding of the radiation sensitivity of organisms other than humans is a basic requirement for planning and regulating the protection of the environment. Currently there are large gaps in the information required to address these concerns, particularly for chronic low-level radiation exposure of non-human organisms. Because of obvious difficulties, not all organisms can be investigated, especially in their natural settings. Birds, because of their reported sensitivity to environmental stress have been studied extensively in the field. It is therefore proposed to conduct an in-field study to examine the effects of low-level chronic radiation on different biological end-points of birds.

It is anticipated that the results of this study will provide greater insight into the effects of radiation on organisms in general, since the biological end-points examined in this work are common to most species.

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Létourneau, M. Measures)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$70k	$0k	$0k	$70k

Earlier Directly-Related Contracts and Funding:

3.151.1 Canadian Data Base for Radionuclide Transfer in the Environment

It is proposed to construct a computer database for radionuclide transfer in the Canadian environment.

This project is proposed because the lack of adequate data on parameters used to predict transfer of radionuclides in the environment often leads to global use of data from relatively few sources. However, Canada has now acquired a substantial amount of data from studies done by several industries and universities, some of it through AECB funding. These data are preferable for Canadian applications and are now available in published and unpublished reports. There is a clear need for a central data source that represents Canadian experimental conditions and is amenable to future updates and that is easily accessible to Canadian investigators and others, including the AECB. This project will define the necessary scope of the data base, select the operating methods (software, repository of the data base, etc.), and acquire, record and interpret suitable data.

It is anticipated that this project will provide AECB staff with convenient access to a comprehensive and centralized data source, which can be used in evaluating licensees' submissions for derived release limits.

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Létourneau, M. Measures)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$30k	$5k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

3.152.1 Production of Public Information Material on the Effects of Radiation

It is proposed to produce a bilingual, non-technical video and accompanying brochure of up-to-date information on the effects of radiation on humans and on the environment.

At present, there are only a few commercially available video productions on the effects of radiation. Most of these videos are produced in the U.S.A. and are relatively old. AECB staff have been using this information material for training purposes and to inform the public about the effects of exposure to radiation. However, AECB staff feel strongly that these videos are outdated and of limited usefulness. Furthermore, little has been produced about the effects of radiation on the environment. This project is proposed because it is felt that up-to-date information in video format (with accompanying brochure), in both official languages, is urgently needed to carry out effective public information programs.

The product of this work will help AECB staff to disseminate, in an effective manner, appropriate, factual and up-to-date information to the Canadian public on the effects of radiation on humans and the environment. These materials also will enhance the visibility of the AECB.

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Létourneau, R. Chatterjee), OPI (H. Spence)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$50k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

3.155.1 Validation of Environmental Pathways Analysis Models

It is proposed to review the progress of, and possibly participate in, the relevant international coordinated research programs aimed at validating environmental pathways analysis models. It is also proposed to evaluate critically the outcome of these programs with a view to identifying whether there is a need for significant changes to the pathways analysis models, currently used by the licensees as approved by the AECB.

In the wake of the Chernobyl nuclear reactor accident, several national (mostly European) and international agencies have been involved in estimating the radiation dose to members of the public through various environmental pathways analyses. During the course of these efforts, it was generally recognized that there were wide variations in the dose predictions, and that the variations depended on the model used. As a result, two international coordinated research programs, called Validation of Model Predictions (VAMP) and Biospheric Model Validation Study (BIOMOVS), have emerged; the former was organized by the IAEA and the latter by the Swedish National Institute of Radiation Protection. Environmental pathways analysis models are used by AECB licensees to derive release limits for nuclear facilities and to predict doses to members of the public from waste management practices. This project is proposed because AECB staff review and assess the models used and the dose estimations prepared by its licensees.

It is anticipated that a critical evaluation of the results of the relevant international programs, and participation in such programs, by AECB staff will help to ensure the credibility of modelling activities in Canada and regulatory decisions based on such modelling. Joint funding, from other interested Canadian agencies, will be sought.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Létourneau)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$70k	$70k	$0k	$140k

Earlier Directly-Related Contracts and Funding:

3.156.1 An Analysis of Brittle Structures in the Saguenay Earthquake Areas

It is proposed to examine and evaluate outcrop-scale faults in the Saguenay Region of Quebec, to measure fault orientations, determine the nature of faulting and identify the faults along which repeated movements have occurred. The study will focus on, but will not be limited to, the epicentral area of the Saguenay earthquake. This project has been endorsed by MAGNEC.

This study is proposed because the 1988 Saguenay earthquake was well located but, to date, knowledge of the causative fault is non-existent. Recent work, by Dawers and Seeber, on the Goodnow and Ardsley earthquakes in New York State has provided encouraging information on faults in seismically active areas.

It is anticipated that the results of this study will shed light on the fault, or fault zone, movement along which was responsible for the Saguenay earthquake. This background information on the potential relationship between earthquakes and major faults could be of use in licensing considerations relating to the design of existing or future nuclear facilities.

Proponent	SSS
Technical Advisor/Evaluator	DRR (Z. Domaratzki), SSS (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$20k	$40k	$80k

Earlier Directly-Related Contracts and Funding:

3.157.1 A Field Evaluation of Convoluted Laminations

It is proposed to select at least three exposures in which convoluted laminations occur and thoroughly map the structures and the entire sedimentary sequence. The environment of deposition will be determined and the origin of the convolutions will be assessed in light of the sedimentary environment. Experimental work may be a part of this study. This project has been endorsed by MAGNEC.

This study is proposed because convoluted laminations are indicators of a sudden shock being applied to water-laden sediments. They are fairly common in the unconsolidated glacio-fluvial sediments of eastern Canada, but their origin is in question. There are classical interpretations related to rapid sedimentation, ice loading or boulders dropping into sediments from freely floating, but progressively melting, ice blocks. However, there is the distinct possibility that they are caused by earthquakes, whether tectonically induced or triggered by sudden shocks attendant upon glacial rebound. Knowledge of the origin of these features could have implications for seismic risk assessments.

It is anticipated that the results of this study will provide evidence that all convolutions do, or do not, form in the same sedimentary environment. If the former, then field evidence would suggest that a sedimentary origin is very likely, although seismicity cannot be ruled out. If, however, these structures form under a variety of sedimentary conditions and if these include quiet water conditions, a seismic origin would seem rather likely.

Proponent	SSS
Technical Advisor/Evaluator	DRR (Z. Domaratzki), SSS (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$25k	$25k	$45k	$95k

Earlier Directly-Related Contracts and Funding:

4. URANIUM MINES AND MILLS

4.101.1 Study of the Health Effects of Inhaled Uranium Ore Dust

It is proposed to provide funding for the ongoing project to study the health effects (induction of cancer of the lung, cellular defects) on experimental animals exposed to different concentrations of airborne high grade uranium ore dust. Inter-organ transfer of radionuclides, such as uranium, radium and thorium, and the rate of clearance of these radionuclides from the lung will also be studied.

This study was undertaken because Canadian uranium miners are exposed to airborne mineral dust that contains uranium, thorium, and all their decay products, some of which are highly radiotoxic. In high grade ore mines, uranium content in the dust may reach several tens of percent and may represent the predominant occupational radiation hazard. Since uranium miners have always been exposed to a mixture of external gamma radiation and internal radiation from radon decay products and ore dust, it has not been possible to separate the contribution of each component to the observed rate of lung cancer. This was of little consequence as long as radon daughters were the predominant hazard, but this becomes an issue in today's Saskatchewan mines. Since the initiation of this project, the following results have been obtained: an apparatus that generates stable high concentrations of uranium ore dust has been built and tested; an on-line aerosol particle sizer monitors continuously the concentration and size distribution of the dust to which the animals are exposed; a nose-only inhalation apparatus (for rats) has been built (according to past experience at National Radiation Protection Bureau) and tested; the renal toxicity of high grade uranium ore dust has been studied and the maximum tolerable (in the short-term) lung burden determined; the resistance of a North American breed of Sprague-Dawley rats to a cancer promoter (5,6-benzoflavone) has been verified. A preliminary long-term (14-week) inhalation experiment has been initiated to determine optimum exposure conditions for the full-scale inhalation experiment, which will last about 24 months.

In addition to the partial information already obtained, it is anticipated that this study will indicate whether inhaled high grade uranium ore dust induces lung cancer in rats whose response to radon daughters is already known. Short- and long-term metabolism of the most significant naturally-occurring radionuclides will also be studied and the data will be used to refine current internal dosimetric models.

Proponent	UFD, RPD, HES
Technical Advisor/Evaluator	UFD (A. Balint), RPD (F. Horvath)
Project Manager	P. Duport
Review Panel	3
Contractor	MacLaren Plansearch Inc.
Principal Investigator	A. Van der Vooren
Category	1*

Past	89/90	90/91	91/92	Future	Total
$555k	$230k	$200k	$111k	$0k	$1096k

Earlier Directly-Related Contracts and Funding:

4.103.2 Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities

It is proposed to continue funding this project to determine experimentally the size distribution, the activity distribution and the solubility of airborne uranium-bearing aerosols in all Canadian uranium mines and mills, refineries, conversion facilities and fuel fabrication plants.

This work is proposed to quantify the hazard presented by airborne radioactive long-lived materials in the concerned facilities. The parameters (size distribution, activity distribution, radionuclide composition and dissolution rate in simulated lung fluid) which are necessary to calculate the committed effective dose equivalent from exposure data must be determined in order to evaluate quantitatively this specific radiation hazard.

It is anticipated that this study will indicate the magnitude of the risk from long-lived particulates in uranium producing and manufacturing industries. It will also provide supporting information for any forthcoming regulation on long-lived dust and will facilitate interpretation of bioassay data for the purpose of the radiation protection of the workers at these facilities.

Proponent	UFD, RPD
Technical Advisor/Evaluator	UFD (G. MacDonald), RPD (F. Horvath, S. Ching)
Project Manager	K.P. Ho
Review Panel	5
Contractor	MacLaren Plansearch Inc.
Principal Investigator	A. Van der Vooren
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$78k	$125k	$60k	$31k	$0k	$294k
Earlier Directly-Related Contracts and Funding:						
84.3.22	$49000	$0	$0			$49000

4.106.3 Ontario Miners Mortality Study - Phase III

It is proposed to continue funding the investigation of the cause of excess lung cancer among miners in Ontario, by updating the mortality analysis for Ontario uranium miners for the period from 1981 to 1986 and for gold miners from 1977 to 1986, in order to re-evaluate the risk of lung cancer per unit exposure of radiation.

This project is proposed because there is a need for an extension of the Phase II study (4.106.2) where excess lung cancer among gold miners and the influence of smoking on the incidence of lung cancer among uranium miners were investigated. The Phase II study recommended that the mortality analysis of gold miners should be extended from 1977 to 1986 to evaluate the impact of gold mining experience on the risk estimate for lung cancer among uranium miners.

It is anticipated that the results of the study will be used to improve the risk estimates for radiation-induced lung cancers. (This is a joint project with the Workers' Compensation Board of Ontario and Ontario Ministry of Labour, each of which will contribute about $50k to this phase of the project.)

Proponent	UFD, RPD, HES, OML (R.A. Kusiak)
Technical Advisor/Evaluator	UFD (A. Balint), RPD (M. Measures, S. Ching)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	Ontario Ministry of Labour
Principal Investigator	R.A. Kusiak
Category	1*

Past	89/90	90/91	91/92	Future	Total
$25k	$20k	$8k	$0k	$0k	$53k

Earlier Directly-Related Contracts and Funding:

4.106.1	$60000	$0	$0		$60000
4.106.2	$180000	$0	$0		$180000

4.106.4 Ontario Miners Mortality Study - Annual Update

It is proposed to update the mortality, exposure and smoking data of the Ontario uranium miners for the two-year period 1987 and 1988 and annually thereafter until FY 1992/93, at which point a detailed mortality analysis will be conducted to obtain improved risk estimates.

The previous phases of the Ontario Miners Mortality Study have revealed that the update on an annual basis of mortality and histology data, as well as exposure and smoking histories, is useful for detecting any annual trend in the mortality pattern, and any influence of yearly variation of smoking habits on the incidence of lung and other cancers among the aging population of Ontario uranium miners. Furthermore, the annual update could be pooled together every five years and the updating of risk estimates could be achieved with minimum delay and cost.

It is anticipated that the results of this study will considerably improve the efficiency of the five-year mortality analysis for lung cancer risk estimates. Furthermore, the annual update will enable the AECB to detect annual trends in the mortality pattern, and the influence of confounding factors on the induction of lung and other cancers among the uranium miners. (This project is expected to be a joint study with Ontario Ministry of Labour (OML) and Workers' Compensation Board of Ontario (WCB) on a one-third cost-sharing basis.)

Proponent	UFD, RPD, HES, OML, WCB
Technical Advisor/Evaluator	UFD (A. Balint), RPD (M. Measures, S. Ching))
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$10k	$10k	$10k	$30k
Earlier Directly-Related Contracts and Funding:						
4.106.1	$60000	$0	$0			$60000
4.106.2	$180000	$0	$0			$180000
4.106.3	$53000	$0	$0			$53000

4.108.1 Intercomparison of Aerosol Sampling Instruments

It is proposed to conduct a literature review, followed by laboratory and field intercomparisons, of the sampling characteristics of two cascade impactors (the Sierra #210 and the Marple Personal Cascade Impactor) which are used to determine the size distribution parameters (Activity Median Aerodynamic Diameter (AMAD) and Geometric Standard Deviation (GSD)) of aerosols. The objective is to evaluate the accuracy and reliability of the Marple Personal Cascade Impactor (in comparison with the more sophisticated Sierra #210) as a tool for verifying, at frequent intervals, the AMAD and GSD of long-lived radioactive dust in uranium-producing facilities. The adequacy of long-lived dust samples (in terms of the total radioactivity) as measured by a portable cyclone instrument and the CEA Personal Alpha Dosimeter (PAD) will be evaluated against open face and cascade impactor samples.

This project is proposed because the AECB is considering using the combined formula recommended in the ICRP Publication 30 for calculating the Committed Effective Dose Equivalent (CEDE) received by uranium workers. Since the Annual Limit on Intake (ALI) for long-lived dust is a function of the AMAD of the aerosols and in order to calculate the radiation doses due to the inhalation of long-lived dust, it is necessary to know the total concentration of radioactivity in the air and the AMAD of the dust. Personal cyclones provide a measure of the dust particles in the size range from 0.5 micron to 5 microns, but neglect particles smaller than 0.5 micron and larger than 5 microns, which also contribute to the radiation dose. The fraction of the total dust collected by cyclones depends upon the AMAD and GSD of the total size distribution. The CEA-PAD provides a measure of the total radioactive dust concentrations but has not been evaluated for this purpose in Canadian facilities. In order to obtain the information necessary for determining individual radiation doses due to exposure to long-lived dust, it is therefore necessary: a) to determine the suitability and reliability of a personal cascade impactor, which will be used to verify the AMAD and GSD of long-lived dust at the work place; and b) to assess to what extent dust samples, collected with portable cyclones and the CEA-PADs, are affected by variations of the AMAD and GSD of the dust, and what impact variations of these parameters may have on dose calculations.

It is anticipated that this study will indicate whether the Marple Personal Cascade Impactor can be used for routine determination of the AMAD and GSD of long-lived radioactive dust in uranium mines and mills, how variations in the AMAD and GSD of the dust affect sampling characteristics of portable cyclones and CEA-PADs, and how variations of these parameters should be taken into account to calculate the doses attributed to long-lived dust from dust measurements taken with personal cyclones and CEA-Personal Alpha Dosimeters.

Proponent	UFD, RPD
Technical Advisor/Evaluator	UFD (K. Bundy), RPD (S. Ching)
Project Manager	K.P. Ho
Review Panel	
Contractor	CANMET Elliot Lake Laboratory
Principal Investigator	Dr. J. Bigu
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$40k	$50k	$0k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

4.113.1 Tracer Gas Method for Assessing Ventilation Efficiency

It is proposed to identify and test a tracer gas technique that is suitable for measuring ventilation rates in underground uranium mines and mills. Phase I of the work includes identifying portable, rugged, and easy-to-use equipment that can function in underground mines and in mill environments, and that allows several measurements to be made in a short period of time. Phase II includes the acquistion and testing of the equipment at selected sites in a mine and mill.

This project is proposed because, in the performance of inspections of uranium mines and mills, AECB inspectors have encountered a number of situations where measurement of air flow directions or flow rates (for the purpose of evaluating the radiation protection efficacy of the ventilation system) has been difficult. Recent advances in the use of tracer gas techniques may be able to overcome the difficulties involved in performing these measurements in currently troublesome ventilation situations.

It is anticipated that a suitable tracer gas method (and related equipment) would permit AECB inspectors to evaluate more quickly and accurately the efficacy of ventilation systems of mine and mill licensees.

Proponent	UFD
Technical Advisor/Evaluator	UFD (D. Corkill), RPD (S. Ching)
Project Manager	P. Duport
Review Panel	
Contractor	CANMET Elliot Lake Laboratory
Principal Investigator	J. Bigu
Category	1*

Past	89/90	90/91	91/92	Future	Total
$25k	$35k	$2k	$0k	$0k	$62k

Earlier Directly-Related Contracts and Funding:

4.117.1 Evaluation of Long-Lived Dust Exposures from Silica Samples

It is proposed: a) to assess, from the available literature, to what extent dust samples (collected in Canadian uranium mines for the purpose of determining exposures to silica dust) are suitable for evaluating individual exposures to long-lived dust with an accuracy acceptable to the AECB; b) if warranted by the results of a), to determine experimentally the correlation between the mass of quartz collected (on total or respirable dust samples) and the alpha activity emitted by the long-lived radionuclides embedded in the dust particles; c) to determine the suitability and sensitivity of silica dust measurements for determining individual exposures to long-lived dust; and d) to evaluate the cost-effectiveness of the technically-acceptable monitoring method(s). This project will be undertaken, if required, only after a thorough AECB internal review of previous studies carried out by EMR on this subject.

The implementation of the Proposed General Amendments to the Atomic Energy Control Regulations will require that each and every radiation hazard present in the work place be taken into account for the determination of individual exposures. In the case of the uranium mining and milling industry, this will require in particular that individual exposures to airborne long-lived dust be evaluated and entered together with gamma, radon daughter and thoron daughter exposures, into a formula from which individual doses and committed effective doses will be calculated. At present, there is no method used routinely in Canadian mines that is known to be able to provide reliable information on long-lived dust exposure. However, silica (or quartz) concentration in mine atmospheres is monitored routinely because of the risk to mine workers of silicosis. It is useful to study to what extent dust samples collected for silica monitoring are suitable for evaluating individual exposures to long-lived dust. In the event these samples are not suitable for evaluating individual exposures to long-lived dust with the required accuracy, alternate methods, such as random spot sampling and the use of personal integrating monitors will be tested in order to determine the most cost-effective technique to be used to meet the upcoming regulatory requirements.

It is expected that this study will indicate to the AECB whether current silica dust samples can be used to evaluate individual exposures to long-lived dust in uranium mines and mills. In the event these samples are found to be unsuitable for this purpose, the study will indicate the most cost-effective method to be used to meet the regulatory requirements.

Proponent	UFD, HES
Technical Advisor/Evaluator	UFD (G. MacDonald)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	2

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$25k	$50k	$15k	$90k

Earlier Directly-Related Contracts and Funding:

4.118.1 Evaluation of Exposure Records of Eldorado Uranium Miners

It is proposed to continue funding the re-examination of the radon daughter exposures of miners who worked at Beaverlodge Uranium Mines (of the then Eldorado Nuclear Limited) in Saskatchewan for the period from 1952 to 1983, and who may have had previous exposures to radon daughters at other mines.

There is some concern about the accuracy of the exposure estimates used in recent epidemiological studies of the Beaverlodge uranium miners. Therefore it has become necessary to re-examine the exposures of individual miners, taking their exposures received in other mines and their work histories into account.

It is anticipated that the results of this study will be used with other specific epidemiological studies, of miners exposed to radon daughters, to improve risk estimates for lung cancer.

Proponent	RPD
Technical Advisor/Evaluator	RPD (S. Ching, C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	17
Contractor	Senes Consultants Ltd.
Principal Investigator	Dr. D.B.Chambers
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$59k	$18k	$0k	$0k	$77k

Earlier Directly-Related Contracts and Funding:

4.118.2 Mortality Analysis of Beaverlodge Uranium Miners from 1981-1987

It is proposed to update the mortality analysis of the uranium miners in Beaverlodge, Saskatchewan, from 1981 to 1987, using computerized linkage to the Canadian Mortality Data Base at Statistics Canada. Additionally the cancer incidence data for this cohort from 1975 to 1987 will also be analyzed to improve the statistical significance of the mortality information which will be used to obtain revised risk estimates for lung cancer per unit exposure to radon daughters.

The risk estimate for lung cancer obtained from the previous mortality analysis of the Beaverlodge uranium miners for the period from 1950 to 1980 was about three times the values reported for the Newfoundland fluorspar miners, about three to six times the values reported for the Ontario uranium miners, and six to nine times the risk estimates obtained from the study of uranium miners in the Colorado Plateau. There is some concern, both nationally and internationally, about the accuracy of the risk estimate obtained from the study of Beaverlodge uranium miners. As a consequence, both the mortality data and radon daughter exposure estimates should be re-examined in order to reduce the uncertainties in the risk estimates. (The re-evaluation of radon daughter exposures is being carried out in another study.)

It is anticipated that the results of this study will improve the risk estimates for lung cancer due to exposure to radon daughters. (This is expected to be a joint study with the National Cancer Institute of Canada on an equal cost-sharing basis.)

Proponent	RPD, HES, NCIC (G. Howe)
Technical Advisor/Evaluator	RPD (C. Pomroy, S. Ching)
Project Manager	V. Elaguppillai
Review Panel	2
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$15k	$45k	$0k	$60k
Earlier Directly-Related Contracts and Funding:						
4.118.1	$0	$77000	$0			$77000
7.095.1	$59000	$0	$0			$59000

4.119.1 Evaluation of Mine Ventilation Monitoring Devices

It is proposed to identify the devices that are currently available for continuous and instantaneous sampling of air velocity and pressure. A side-by-side comparison will be undertaken of accuracy, reliability and ruggedness of representative devices when these devices are subjected to environmental conditions similar to those found in underground uranium mines and in mills.

This study is proposed because ventilation systems used to reduce the radioactive contamination in mine and mill air must be maintained at their optimal performance, requiring continuous auditing by mine and mill staff. Some types of the traditional mechanical air velocity and pressure-measuring equipment are becoming obsolete and are being replaced by electronic devices. Information on the operating capabilities of modern devices, and their ability to provide accurate and reliable data when used in the cold, damp, dusty environments of underground uranium mines, and dusty atmospheres of uranium mills, is required by the UMD to assess the radiation protection methods used by licensees.

It is anticipated that the results of this study will enable the UMD to prepare a regulatory guideline, for use throughout the uranium mining industry, for the measurement of air velocities and pressures.

Proponent	UFD
Technical Advisor/Evaluator	UFD (D. Corkill)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

4.129.1 Temporal Variation of Airborne Radioactivity in Mines

It is proposed to collect a large number of data on the concentration of radon decay products, thoron decay products, and long-lived radioactive dust in the atmosphere of representative workplaces in uranium mines and mills, and to determine the variability of these concentrations over time. This will be done with a view to determining sampling schedules that lead to sufficiently accurate estimates of individual exposures.

It is current practice, in Canada, to measure the instantaneous concentrations of radon and thoron decay products, and of long-lived radioactive dust in the air, and to estimate individual exposures to these pollutants from these measurements. Individual exposures to airborne pollutants in uranium mines are calculated from the mean of the concentrations measured, and the time spent by the individual, at the workplace. Current practices have monitoring frequencies as low as one sample per month. However, in every instance where a series of samples at a workplace has been taken with high frequency, it has been observed that the concentration of the pollutants of concern is variable, with a range of variation that can reach one or two orders of magnitude. As a consequence, it is impossible to quantify the uncertainties in the exposures attributed to individual workers from instantaneous measurements. In order to determine whether a monitoring programme actually provides data from which exposures can be estimated with a pre-set level of uncertainty, it is necessary to collect a sufficient number of measurements of concentrations and to study their variability. These data will be analyzed according to procedures that are suggested in AECB INFO-0038 and 0075.

It is anticipated that the information provided by the study will permit AECB staff to determine whether present air sampling protocols, proposed by licensees, allow sufficiently accurate calculation of individual exposures to demonstrate compliance with the AEC regulations.

Proponent	UFD
Technical Advisor/Evaluator	UFD (K. Bundy), RPD (S. Ching, F. Horvath)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

5. WASTE MANAGEMENT

5.127.1 Radionuclide Concentrations in Fish: Phase I Screening Program

It is proposed to obtain samples and determine the concentrations of radionuclides (Ra-226, first) in fish and in the associated water and sediments taken from the fish-stocked lakes found downstream of the Elliot Lake uranium mines in the Serpent River Basin. Further it is proposed that transfer parameters be calculated for each radionuclide (from sediments to water to fish to consumer) and that dose to humans consuming these fish be estimated. Based on these results for Ra-226, analysis of certain other radionuclides of the uranium and thorium decay chains , in fish, water, and sediment samples, will be performed with the similar objective of calculating transfer parameters and estimating dose.

Transfer parameters for the uranium and thorium decay series in aquatic ecosystems are important components in the estimation of public dose arising from uranium mining activities. Results of a recent report, 'Survey of Data on the Radionuclide Content of Fish in Canada' INFO 0231-1, indicated that there were very few studies of radionuclide concentrations in fish and associated water and sediment, and that there have been very few studies on these subjects conducted in Ontario. This project is proposed because additional data would be useful to more accurately estimate the dose to the public resulting from consumption of fish in the Elliot Lake area, which accounts for all of Ontario's uranium production.

It is anticipated that the results of this study will provide reliable information to assess the dose from ingestion of fish by people in Elliot Lake; in addition, site-specific transfer coefficients will be obtained.

Proponent	WMD
Technical Advisor/Evaluator	WMD (W. Napier, B. Zgola), RPD (C. Létourneau)
Project Manager	R. Avadhanula
Review Panel	11
Contractor	
Principal Investigator	Dr. F . V. Clulow
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$35k	$35k	$0k	$0k	$70k

Earlier Directly-Related Contracts and Funding:

5.134.1 International Conference on Transport Processes in Aquifers

It is proposed that the AECB co-sponsor the 1990 international conference and workshop on "Transport Processes in Aquifers" to be held October 2-5 in Ottawa.

The main objective of the conference and workshop is to provide a forum for the presentation and discussion of two important scientific problems currently facing scientists working on safe disposal of radioactive waste: "How well can currently available models predict the movement of contaminants in heterogeneous geologic media?" and "What methods are currently available for aquifer characterization and at what spatial scales can they be used for quantifying heterogeneities in geologic media within the framework of available models?". The workshop participants are, generally, scientists dealing with research in radioactive waste management and represent about 15 countries. This one conference will bring together the expertise of modellers and field hydrogeologists.

AECB staff will benefit from obtaining the most current information on the reliability of various models and from identifying deficiencies in the understanding of the complex hydrogeologic processes involved with the transport of radioactive contaminants.

Proponent	WMD, RPD, HES
Technical Advisor/Evaluator	WMD (D. Metcalfe)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$5k	$0k	$0k	$5k

Earlier Directly-Related Contracts and Funding:

5.135.1 Frost Evolution in Tailings

It is proposed to: a) review the mechanisms of frost evolution in soils, generally, and in uranium tailings in particular; b) review critically existing computer models of permafrost evolution; c) select and install one such computer model on a computer system (to be defined); and d) run the model for one typical tailings impoundment facility, to demonstrate the model's features.

Many present or planned uranium tailings facilities in Canada are in zones of discontinuous or continuous permafrost. Frost formation in tailings has desirable as well as undesirable consequences. When tailings are frozen, the pore water is practically immobile and thus leaching of contaminants to the surrounding groundwater is virtually nil. Nevertheless, especially in zones of discontinuous permafrost, frozen zones in the tailings mass will not remain frozen but will thaw and refreeze. When thawing occurs, the tailings mass will consolidate resulting in higher release of contaminants to the environment, differential settlement at the surface leading to failure of covers and caps, and potential liquefaction of tailings resulting in instability of confining dams. This project is proposed because it is important to be able to predict the evolution of these frost zones within the tailings mass.

It is anticipated that the results of this project will provide AECB staff with a state-of-the-art understanding of the mechanisms of frost evolution in tailings, and a tool to predict this evolution. These will be used to assess licensees' submissions relevant to this important safety aspect of tailings facilities.

Proponent	WMD
Technical Advisor/Evaluator	WMD (S. Nguyen, B. Zgola)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$70k	$30k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

5.136.1 Hydrology of Quirke and Panel Tailings Basins

It is proposed to perform post-decommissioning, hydrologic calculations for the Quirke and Panel tailings basins in Elliot Lake. The parameters of interest resulting from these calculations will be water levels and flow quantities at critical points of the watershed, both under average operating conditions and during unusual storm events. These parameters will be used to assess the adequacy of the dams' freeboard and the capacity of the spillways.

Rio Algom has proposed using a "saturated tailings" concept, to decommission the Quirke and Panel tailings sites in Elliot Lake. The objective is to prevent acid generation, which occurs in the unsaturated zones where the water table is kept below the tailings surface. The requirement of a high water level in the tailings mass necessitates a very careful design of the dam freeboard and the spillway capacity, since the most important cause of dam failure is overtopping. The licensee has provided hydrologic calculations to support the design of these freeboards and spillways. These calculations are very sensitive to the analyst's experience, and to the particular model used. This project is proposed because, in order to have more confidence in the adequacy of the design, a second professional opinion is needed.

It is anticipated that the results of this project will help AECB staff gain more confidence in the adequacy of the licensee's design of dam freeboards and spillway capacities. Inadequate design would totally defeat the "saturated tailings" decommissioning concept.

Proponent	WMD
Technical Advisor/Evaluator	WMD (S. Nguyen, B. Zgola)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$60k	$0k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

5.138.1 Review of Uranium Solubilities

It is proposed to fund a contract to conduct a critical review of uranium dioxide solubilities under a variety of geochemical conditions.

Scoping assessments demonstrate the critical safety role played by the solubility of the uranium fuel matrix. Thus a greater understanding of its value and relationship to Eh, pH, and other dissolved species is necessary for the safety evaluation process.

The results of the contract will be used in the review of the Canadian Nuclear Fuel Waste Management Program (CNFWMP), and to support AECB statements about the concept for high level waste disposal during public hearings.

Proponent	WMD
Technical Advisor/Evaluator	WMD (P.A. Flavelle)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

5.139.1 Dissolution of Fuel Matrix - Analog Studies

It is proposed to fund a contract to investigate critically the assumption of congruent dissolution of spent fuel by examining existing mineralogical evidence on the history and genesis of naturally-occurring uranium oxide components in a variety of geochemical settings.

Calculations by AECB staff have indicated that congruent dissolution of fuel helps limit the rapid release of some toxic radionuclides. It is possible that, in the Canadian Nuclear Fuel Waste Management Program (CNFWMP), an attempt will be made to demonstrate that this is the normal release mechanism under repository conditions over long time periods. Natural mineral systems should be able to demonstrate whether or not this is the case and thus will be useful in the overall safety analysis being developed by AECB staff.

The results of the contract will be used in in the review of the CNFWMP, and to support AECB statements about the concept for high level waste disposal during public hearings.

Proponent	WMD
Technical Advisor/Evaluator	WMD (P.A. Flavelle)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

5.140.1 Link between Ore Bodies and Biosphere Concentrations of Metals

It is proposed to fund a contract to examine evidence that suggests that natural systems are capable of limiting the amount and concentration of metals which enter the accessible environment from natural concentrations of ore bodies.

This study will examine naturally-occurring element distributions. This could help judge the validity of some of the models which are used to forecast the effectiveness of the geological barriers in isolating wastes, and could also help form qualitative analogs useful in assessing the safety of the waste disposal concept.

The results of the contract will be used in the review of the Canadian Nuclear Fuel Waste Management Program (CNFWMP) and to support AECB statements about the concept for HLW disposal during public hearings.

Proponent	WMD
Technical Advisor/Evaluator	WMD (P.A. Flavelle)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$25k	$0k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

5.141.1 Review of Groundwater Dating and its Relation to High Level Waste Disposal

It is proposed to fund a contract to critically review existing literature and methods on groundwater dating and to assess the degree to which this information can be used to support long-term geological isolation of high level waste in Canada.

Model studies indicate long-duration flow paths from a deep repository. This study would assess whether groundwater dating techniques can be applied to analog sites to support or validate these assessments.

The results of the contract will be used in the review of the Canadian Nuclear Fuel Waste Management Program (CNFWMP), and to support AECB statements about the concept for high level waste disposal during public hearings.

Proponent	WMD
Technical Advisor/Evaluator	WMD (P.A. Flavelle)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$15k	$0k	$0k	$15k

Earlier Directly-Related Contracts and Funding:

5.142.1 Feasibility of Monitoring Tailings Sites Using Remote Sensing

It is proposed to investigate the potential use of remote sensing techniques to monitor uranium mine and mill tailings disposal areas. First, the technical feasibility of using remote sensing to monitor tailings disposal areas will be investigated. This will include discussions of the type, limitations and usefulness of information available from sensors mounted in either aircraft or satellites. As well, the economic feasibility of collecting, processing and interpreting this information will be discussed. The study will compare and contrast the cost, advantages and disadvantages of the techniques that provide useful information. The second phase, contingent upon the successful completion of the first phase, will be a demonstration of the most promising remote sensing techniques using existing data for a real site located in the Elliot Lake area.

After uranium mines have closed, the Crown will eventually resume responsibility for the mine site, including the mill tailings disposal areas. The report "The Cost of Decommissioning Uranium Mill Tailings" (INFO-0198, 1986), commissioned by the AECB, recommends using aerial photography for routine monitoring of the conditions of tailings disposal areas after they have been decommissioned but are subject to institutional controls. The routine monitoring would be used to determine when (or if) contingency plans or remedial actions need to be initiated. The cost to obtain and interpret aerial photographs is estimated in the above report to be about $10,000 (Can. 1985) per survey. Other remote sensing techniques may be a cost-effective alternative to aerial photography and provide more useful quantitative information for the routine monitoring of tailings disposal areas. For example, Multi-Spectral Scanners and Thematic Mappers provide digital data which can be manipulated for a variety of interpretations. Mounted in an aircraft , they can achieve very high spatial resolution, while satellite-mounted remote sensors can image an area as frequently as every eight days. Also, there exists an archive of images from when the satellites first began operation, which may provide baseline data for existing mine sites.

If technologically feasible, the cost of routine monitoring of relatively inaccessible decommissioned tailings areas may be reduced significantly by using remote sensing techniques. It is anticipated that a large portion of the cost of a remote monitoring program would be in the initiating phase, so such programs should be instituted while current tailings disposal areas are still operational, to take advantage of on-site resources and facilities that will not be available after decommissioning. Such programs should also be instituted prior to planned mining to investigate baseline conditions, and such baseline data may be available for existing tailings disposal areas in archived satellite imagery. (The cost estimate given below is for the first phase only.)

Proponent	WMD
Technical Advisor/Evaluator	WMD (B. Zgola)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

6. NON FUEL CYCLE APPLICATIONS

6.102.1 Radiation Doses to Technologists from Radiotherapy

It is proposed to measure and compare the radiation doses received by radiotherapy technologists during performance of their duties on two different types of treatment machines (high energy accelerators and cobalt-60 machines). The aim of the project is to determine: a) the doses received by technologists working on cobalt-60 and high energy linear accelerators (≥10 MeV); b) the dose uniformity amongst technologists (since the dose results from the "head" of the machine which is normally above the technologist, the dose to the upper part of the body could be significantly higher than to the waist area where the TLD badge is often worn); and c) the contributions to the exposure from working inside the treatment room during the setting up of patients and from working at the control console of the machine.

This work is proposed because, in order to reduce the radiation exposure received by technologists in a radiotherapy department, it is necessary to identify the significant sources of exposure and their relative magnitudes. Also, the radiation exposures attributed to technologists may vary from machine to machine implying that there may be significant differences in exposure at the various machines.

It is expected that the proposed research will provide information on the relative exposure received by technologists working on the different types of therapy machines From this information, the AECB may be able to infer the mechanism by which the technologists receive the major part of their personal exposures. This information is essential in order to effect changes aimed at reducing personal radiation exposures, including the re-assignment of pregnant technologists to those duties where exposure is minimized, as well as to develop protocols aimed at reducing the radiation exposure to the technologists.

Proponent	RTD
Technical Advisor/Evaluator	OCD (A. Guilbaud), RTD (W.R. Brown), RPD (G. Poirier)
Project Manager	K.P. Ho
Review Panel	
Contractor	Atlantic Nuclear Services Ltd.
Principal Investigator	C. Keith Scott
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$35k	$16k	$0k	$0k	$51k

Earlier Directly-Related Contracts and Funding:

6.105.1 Radiation Exposures of Non-Monitored Hospital Personnel

It is proposed to continue the funding to study the radiological impact of nuclear medicine patients on non-monitored hospital staff. The nuclear medicine patients are those who have had radioisotopes administered to them for the purpose of diagnostic medical examinations. The non-monitored hospital staff of interest in this study are workers who handle or are near nuclear medicine patients during the performance of their duties and who are not monitored for radiation exposures. Examples of these workers are ultrasound technicians, nurses and receptionists in nuclear medicine departments.

This study is proposed because there is a scarcity of information on radiation exposures for these specific job categories within hospitals. In order to assess doses and to verify whether the ALARA principle is being observed, the magnitude of exposures to these categories of workers should be known.

It is anticipated that the proposed research will provide information on the radiation doses and dose rates received by the various job categories. From the information obtained in this study, the AECB should be able to develop guidelines to reduce the radiation exposures, according to the ALARA principle, to non-monitored hospital staff. (This project has been jointly funded with SSC as follows: $36k by SSC and $52k by AECB.)

Proponent	RTD
Technical Advisor/Evaluator	RTD (M. Simard), RPD (G. Poirier)
Project Manager	K.P. Ho
Review Panel	18
Contractor	Université de Montréal
Principal Investigator	L. Renaud
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$48k	$4k	$0k	$0k	$52k

Earlier Directly-Related Contracts and Funding:

6.113.1 Measurements of Radioactive Waste Disposal in Hamilton

It is proposed to measure, for the city of Hamilton, Ontario, the concentration of radioisotopes in sewer, landfill and incineration systems, due to the disposal of radioactive waste.

This project is proposed to confirm with actual measurements at various municipal sites, the appropriateness of the theoretical model for calculating collective and individual doses from disposal of radioactive materials. This model is the result of a previous research project entitled: "Determination of the Radiological Impact of Radioisotope Waste Disposal". INFO-0166

It is anticipated that the results of this study will provide information concerning the limitations of the model discussed above. This model is to be used by AECB staff for compliance purposes.

Proponent	RTD, WMD, HES
Technical Advisor/Evaluator	RTD (R. Brown), WMD (A. Regimbald)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$30k	$40k	$0k	$70k
Earlier Directly-Related Contracts and Funding:						
84.6.1	$64000	$0	$0			$64000

6.114.1 Calculation of Lung Dose following Fluoroscopic Examination

It is proposed to calculate the dose to the lungs of nearly 100,000 Canadian tuberculosis patients (roughly equal numbers of males and females), who were exposed to x-rays during multiple fluoroscopic examination of their lungs, in the period from 1930 to 1952. (This is the single largest group of people ever subjected to multiple exposures of low-LET radiation.)

Several of the 100,000 exposed individuals were later known to have developed breast and lung cancers. To date, only the breast cancer incidence among the females has been analyzed for the purpose of estimating the risk of breast cancer. The risk of lung cancer among these exposed individuals has never been estimated. As a first step, it is necessary to calculate the lung dose received by the exposed tuberculosis patients.

It is anticipated that the dose estimates obtained from this study will be used with the lung cancer mortality data of these cohorts to calculate the risk of lung cancer per unit exposure to x-radiation. The mortality analysis will be carried out in project 6.114.2. (This project is expected to be a joint study with the National Cancer Institute of Canada (NCIC), on an equal cost-sharing basis.)

Proponent	RPD, HES, NCIC (G. Howe)
Technical Advisor/Evaluator	RPD (G. Poirier)
Project Manager	V. Elaguppillai
Review Panel	2
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$25k	$20k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

6.114.2 Mortality Analysis of Persons Subjected to Fluoroscopic Examination

It is proposed to analyze the lung cancer mortality, for the period from 1950 to 1988, among nearly 100,000 Canadian tuberculosis patients (roughly equal numbers of males and females) who were exposed to multiple fluoroscopic chest examinations (x-rays) in Nova Scotia and Ontario. The dose estimates obtained from the preceding project (6.114.1) will be used to calculate the risk of lung cancer per unit exposure to x-rays. In addition, the relative radiosensitivities of males and females for the induction of lung cancer will be examined.

To date, the lung cancer mortality among the tuberculosis patients who were exposed to multiple fluoroscopic irradiation has not been examined. Furthermore, this unique cohort (the single largest group of persons ever subjected to multiple exposures to low-LET radiation) has never been used to derive the risk of lung cancer per unit exposure to low-LET radiation. Therefore, it is prudent to use this unique data base, together with the dosimetric information obtained from the preceding project (6.114.1) to derive risk estimates for lung cancer due to exposure to low-LET radiation. Since this cohort consists of nearly equal numbers of males and females, who were exposed to x-radiation under very similar conditions and dose levels, the AECB has a unique opportunity to determine the relative radiosensitivities of males and females for the induction of lung cancer.

It is anticipated that the results of this study will improve the risk estimates for lung cancer due to exposure to low-LET radiation. Furthermore, the study is expected to reveal the radiosensitive difference (if any) between males and females for the induction of lung cancer. Additionally, the results of the study will be used to determine the correspondence factor between the exposure unit, Working Level Month (WLM), and the dose equivalent unit, sievert (Sv). (This project is expected to be a joint study with the National Cancer Institute of Canada (NCIC) on an equal cost-sharing basis.)

Proponent	RPD, HES, NCIC (G. Howe)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	2
Contractor	
Principal Investigator	
Category	2

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$10k	$50k	$20k	$80k

Earlier Directly-Related Contracts and Funding:

7. HEALTH PHYSICS

7.093.1 Epidemiology of Lung Cancer Mortality in Canadian Mining Communities

It is proposed to fund the ongoing case-control pilot study of lung cancer deaths in uranium and non-uranium mining towns across Canada in which lung cancer mortality has been shown to be significantly elevated.

The study is proposed in order to attempt to find out to what extent various factors in the home and the workplace were responsible for excess cancer among miners and other residents of mining communities.

It is anticipated that the results of this study will be used to improve risk estimates for radiation-induced lung cancers. (A joint study with Statistics Canada and Health and Welfare Canada.)

Proponent	RPD, HES, NHW (D. Wigle), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (S. Ching, C. Pomroy)
Project Manager	P. Duport
Review Panel	
Contractor	Health & Welfare Canada
Principal Investigator	Y. Mao
Category	1*

Past	89/90	90/91	91/92	Future	Total
$70k	$0k	$3k	$0k	$0k	$73k

Earlier Directly-Related Contracts and Funding:

7.101.1 The Canadian National Dose Registry Study

It is proposed to continue funding the project to conduct an epidemiolgical study of cancer mortality among some 300,000 Canadians occupationally exposed to low levels of ionizing radiation, by developing a suitable linkage between the Canadian National Dose Registry and the Canadian Mortality Data Base.

This study is intended to find out whether there is any excess cancer mortality among certain groups of workers, such as Nuclear Medicine Technicians and Radiographers, who have not been studied so far in sufficient detail. This study of 300,000 radiation workers is likely to provide further information towards a better understanding of the dose-response relationship for low doses of ionizing radiation.

It is anticipated that the results of this study will be used to verify risk estimates for radiation-induced cancer mortality. (This is a joint study with the Department of National Health and Welfare and Statistics Canada. NHW has expended considerable resources both in dollars and person-years in support of this project. The expenditure by NHW (estimated to be $1,211K) is in addition to the funds expended by the AECB.)

Proponent	RPD, HES, NHW (P. Ashmore), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (M. Measures, C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	Statistics Canada
Principal Investigator	M. Fair
Category	1*

Past	89/90	90/91	91/92	Future	Total
$279k	$35k	$10k	$0k	$0k	$324k

Earlier Directly-Related Contracts and Funding:

7.106.2 Effects on Central Nervous System from In Utero Exposure

It is proposed to fund a full-scale study of the health effects on the central nervous system (CNS) of experimental animals (rats and monkeys) following in utero exposure to ionizing radiation. Pregnant animals will be exposed to different doses and dose rates of ionizing radiation at different stages of gestation and the corresponding morphological and physical changes in the brain will be assessed quantitatively.

It is anticipated that an increasing number of young women will seek employment in the Canadian nuclear industry, where, in some cases, exposure of embryos or foetuses may occur. Very little information is available in the literature about the effect of in utero irradiation on the function and structure of the central nervous system. A feasibility study (84.8.8) completed in 1986 recommended a full-scale study to make quantitative estimations of the risk of health defects on the CNS following in utero irradiation taking dose, dose rate, and the stage of gestation into account.

The results of the full-scale study will be used to extrapolate, from animals to humans, the risk estimates for radiation-induced developmental defects. (This is expected to be a joint study between the University of Manitoba and the University of California (Davis), on an equal cost-sharing basis.)

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	1
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$30k	$60k	$210k	$300k

Earlier Directly-Related Contracts and Funding:

84.8.8	$22000	$0	$0			$22000

7.118.1 Selection of Control Groups for Epidemiological Studies

It is proposed to fund the development of a unified system of selecting control groups for use in epidemiological studies of radiation-induced health effects.

One of the major problems in interpreting the results of epidemiological studies of groups exposed to ionizing radiation is the general lack of comparability between different studies of similar groups. The main source of the problem is the variation of the basis for selection of control groups used in the different studies. Therefore there is a need to develop a comprehensive system or methodology for selecting control groups for use in Canadian epidemiological studies of radiation-induced health effects. Lack of uniformity in selecting control groups has also been recognized as a weakness in epidemiological studies in other countries.

It is anticipated that the results of this study will provide a unified system or methodology for selecting control groups for use in epidemiological studies of radiation-induced health effects.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	E. Rabin
Review Panel	
Contractor	Epidemiologic Consulting Services
Principal Investigator	Geoffrey R. Howe
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$25k	$25k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

7.119.2 Full-Scale Epidemiological Study of Thyroid Cancer from I-131 Exposure

It is proposed to continue funding the epidemiological study of thyroid cancer among Canadians who were exposed to radioactive iodines during diagnostic examinations.

This project is proposed because risk estimates for radiation-induced thyroid cancer are largely based on the incidence among those exposed to x-radiation. There is some controversy as to whether or not the same doses of I-131 and x-radiation are equally effective for the induction of thyroid cancer. A pilot study (84.8.13), jointly funded by the Alberta Cancer Board and the AECB, recommended a full-scale study at the national level to investigate the relative biological effectiveness of x-radiation and I-131.

The results of the study are expected to refine the risk estimates for radioiodine-induced thyroid cancers, and to determine whether or not equal (thyroid) doses of I-131 and x-radiation are equally effective in the induction of thyroid cancers. (This is a joint study with the ten provincial cancer registries, each contributing $50K, and the Department of National Health & Welfare which is contributing $271K.)

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	V. Elaguppillai
Review Panel	2
Contractor	G.B. Hill Statistics Inc.
Principal Investigator	G.B. Hill
Category	1*

	Past	89/90	90/91	91/92	Future	Total
	$107k	$50k	$5k	$0k	$0k	$162k
Earlier Directly-Related Contracts and Funding:						
84.8.13	$61000	$0	$0			$61000

7.122.1 Computerized Linkage of National Cancer Incidence Data

It is proposed to develop a satisfactory format for the computerized record linkage of national cancer incidence data with personal identifiers of breast and lung cancer patients who were previously exposed to fluoroscopic radiation during pneumothorax examination for tuberculosis.

The reason for proposing a cancer incidence linkage is to identify cancers which have occurred in the cohorts, but which have not been the underlying cause of death, and therefore have not been identified in the usual mortality linkage. This approach has never been used in any epidemiological studies of persons exposed to ionizing radiation.

The results of this study will help to determine whether the occurrence of a particular type of radiogenic cancer in any way yields a different mortality pattern for the same cancer, arising from a non-radiogenic cause. This study may have an impact on the risk estimates which form the basis of the dose limits for ionizing radiation. (This is a joint project with National Cancer Institute of Canada and Statistics Canada, which will jointly contribute $100K to the project.)

Proponent	RPD, HES, NCIC (G. Howe), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	National Cancer Institute of Canada
Principal Investigator	G.R. Howe
Category	1*

Past	89/90	90/91	91/92	Future	Total
$55k	$30k	$35k	$0k	$0k	$120k

Earlier Directly-Related Contracts and Funding:

7.135.1 Mechanism of Radiation-Induced Mental Retardation

It is proposed to conduct a laboratory experiment to study the effect of low doses of ionizing radiation on the migratory characteristics of neurons of mice and of non-human primates. Embryonic neural cells will be cultured, and exposed to different doses of ionizing radiation at different stages of neuronal development. The subsequent changes in the cellular surface structures, the number of cells present to migrate, the rates and the extent of migration of the neurons will be assessed quantitatively using a variety of monoclonal antibodies.

Recently, magnetic resonance imaging and autopsy data have established that a substantial fraction of the radiation-related cases of mental retardation seen in Hiroshima and Nagasaki bomb survivors exhibits evidence of a gross impairment of neuronal migration, seen as ectopic grey matter, largely circumventricular in distribution. It is important to understand the relationship between exposures and impaired migration and the cellular and molecular nature of this impairment in order to derive a quantitative value for the risk of mental retardation following in utero exposure to ionizing radiation.

It is anticipated that the results of this study will provide quantitative information on the mechanism of the impairment of the neuronal migratory processes. This understanding will lead to a better estimate of the risk of mental retardation due to in utero exposure to ionizing radiation. (This is expected to be a joint study with the Radiation Effects Research Foundation of Japan, Kyoto Prefectural University of Medicine (Japan), and the University of Texas Health Sciences Center in Houston. The total cost of the project is about $280k, shared among all sponsors, with an AECB contribution of about $70k over 24 months.)

Proponent	RPD, HES, U. of Texas (W. Schull), Kyota PUM-RERF (S. Fushiki)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	1
Contractor	Schull, W.J.
Principal Investigator	Prof.W.J.Schull
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$25k	$45k	$10k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

7.137.1 Study of Childhood Cancer following Maternal X-irradiation

It is proposed to investigate the incidence of childhood cancer among (i) those children who had abnormal delivery (such as breech presentation) or birth defects (such as Down's Syndrome), but whose mothers were not subjected to irradiation during pregnancy, and (ii) those who received in utero exposure to X-rays, both groups to be compared with suitably selected control populations.

Some controversial studies have indicated an association between maternal exposure to low doses of ionizing radiation (i.e., at levels in the neighbourhood of regulatory dose limits) and the incidence of excess childhood cancers. On the other hand, some recent studies have reported an association between abnormal pregnancy cases (such as breech presentation and Down's Syndrome) and excess childhood cancers, even in the absence of exposure to X-rays during pregnancy or delivery. It is therefore possible that the reported association between maternal irradiation and excess childhood cancer was essentially due to those cases of abnormal pregnancies and deliveries and not necessarily due to maternal irradiation on the incidence of childhood cancer.

The result of this study will improve our understanding of the qualitative association between childhood cancer and maternal irradiation and may improve the quantitative risk estimates for radiation-induced cancers.

Proponent	RPD, HES, UBC (T.W. Anderson)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	2
Contractor	
Principal Investigator	
Category	1*

Past	89/90	90/91	91/92	Future	Total
$0k	$10k	$40k	$15k	$0k	$65k

Earlier Directly-Related Contracts and Funding:

7.141.1 RBE of Gamma Rays Delivered at Low Dose Rates

It is proposed to compare the relative biological effectiveness (RBE) of gamma rays and x-rays in accelerating the development of mammary cancers (adenocarcinomas) in rats, when the radiation is delivered in moderate doses (up to 1 Gy), at low dose rates (of the order of 0.008 Gy/hr).

This project is proposed because the primary hazards of exposure to low levels of radiation at low dose rate are generally considered to be the induction of cancer and of genetic changes. For these endpoints, a task group has recently suggested, in ICRU Report No. 40, that appropriate quality factors suggested for gamma rays and x-rays depend almost exclusively on laboratory studies on endpoints such as the induction of somatic mutations in micro-organisms (Tradescantia). Data obtained recently by Atomic Energy of Canada Ltd., Chalk River, suggest that doses of gamma rays up to about 1 Gy, delivered at dose rates of about 0.008 Gy/hr, have comparatively little effect on the appearance of mammary tumours in Sprague-Dawley rats. This surprising observation requires confirmation. If it can be substantiated, it would suggest that low doses of gamma rays, delivered at low dose rates, produce very few mammary cancers, i.e., the RBE of low doses of gamma rays, delivered at low dose rates, is effectively zero for induction of malignant breast cancers in rats.

It is anticipated that the findings of this study may provide justification for reducing the quality factor below the current value of unity for gamma rays delivered in low doses and at low dose rates. This would impact on the risk estimates for radiation-induced cancer for humans from exposure to gamma rays. (This project is proposed to be cost-shared with AECL on a 50/50 percent basis with a total project cost estimate of $270k.)

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	6
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$33k	$80k	$22k	$135k

Earlier Directly-Related Contracts and Funding:

7.152.1 Transport of Compounds from Mother to Foetus

It is proposed to review and assess the open literature on the transport of compounds (radioactive and non-radioactive) of selected elements from the mother to the embryo/foetus, and on the distribution of the compounds within the embryo, in animal and human systems. This information will provide a comprehensive overview of the processes that regulate transport to, and retention in, the foetus at different times during the gestation period. Another objective of the study will be to develop a general system model for the uptake, retention and excretion of the compounds by the foetus and amniotic fluid.

This project is suggested because the proposed revisions to the Atomic Energy Control Regulations require that the dose to the foetus be estimated, and not merely be assigned the same value as the dose to the abdomen of the exposed mother. In the special case of radiocompounds taken into the body of the mother, direct measurement of fetal doses is not possible, and it is necessary to calculate these doses by means of models which relate the quantity of radionuclides present in the body of the mother, or in excreta, to that which may be present in the foetus at any time. Little information relating these quantities for radiocompounds is available and, accordingly, it is necessary to use relevant information from the much larger body of knowledge available on chemical analogues of the radiocompounds.

It is anticipated that the findings and recommendations from this project will provide a database and a general model which will be used in a sub-program on foetal dosimetry. This sub-program will enable AECB staff and licensees to calculate for compliance purposes, and as accurately as possible, the dose to the foetus from the uptake of radiocompounds by the mother.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy, F. Horvath)
Project Manager	E. Rabin
Review Panel	19
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

7.153.1 RBE of Tritium and Co-60 Gamma Rays at Low and High Dose Rates

It is proposed to examine the effects of tritium beta-rays (from HTO) and Co-60 gamma-rays at "low" (approx. 0.003 Gy/min) versus "high" (approx. 2.0 Gy/min) dose rates, on both DNA repair-proficient and repair-deficient cultured mammalian cell lines, using a variety of biological endpoints (e.g. cell killing, induction of mutations, and other cytogenetic events such as micronuclei and transformations) . The results will be compared to those obtained with 250 kVp x-ray exposures at the same dose rates.

This project is proposed because tritium beta-rays account for a significant portion of the total dose from the operation of CANDU nuclear generating stations, and the estimation of dose rate effects is assuming ever increasing importance in radiation protection programs. Values of RBE for tritium, as reported in the literature, range from about one to two. However, much of this variation may arise as a result of dose rate effects, and from the use of different biological endpoints for determining the RBE. It is necessary to obtain experimental data that will aid in the interpretation of the RBE values reported in the literature.

It is anticipated that the findings of this study will result in an improved understanding of the relationship between dose-rate effects and different endpoints used for determining the RBE for exposures to tritium. This understanding will, in turn, assist AECB staff in evaluating the potential doses and biological significance of exposures to tritium beta-rays. (The study is to be jointly funded by the AECB and AECL on an equal cost-sharing basis: AECB $60k, AECL $60k)

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$40k	$20k	$0k	$60k
Earlier Directly-Related Contracts and Funding:						
7.120.1	$124000	$0	$0			$124000

9. REGULATIONS & REGULATORY PROCESS DEVELOPMENT

9.103.2 Implementation of a New File Classification System

It is proposed to design and implement a new universal indexing scheme for the AECB records management operation that allows ready access to information by AECB staff. This activity was a recommendation of the preceding project 9.103.1, "Study of the AECB Long Range Plan for Information Management".

The subject classification in the current indexing scheme makes it difficult for users to retrieve information on a particular topic. For example, records are often distributed across several different files and if the user does not know which files then the information is effectively unavailable. The problem is analogous to a library in which the books have been catalogued under broad and ambiguous classifications using informal cataloguing rules.

As a result of this project, AECB staff and the public will be able to gain ready access to the knowledge base held in the records management system.

Proponent	IMS
Technical Advisor/Evaluator	IMS (W. Goodwin)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	2

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$15k	$105k	$0k	$120k

Earlier Directly-Related Contracts and Funding:

9.103.1	$73000	$77000	$0			$150000
9.103.3	$0	$0	$80000			$80000

9.103.3 Implementation of New Information Management Plan

It is proposed to implement the new AECB Long Range Plan for Information Mangement resulting from project 9.103.1. The specific equipment, software, training, operational methods and implementation plan would be defined and described in detail and the contractor would assist AECB staff during the actual installation, training, and commissioning of the new systems.

Expert knowledge is required of the most effective means of carrying out the long range plan, from a useability and cost viewpoint. The AECB does not have sufficient in-house resources to do this.

This project would enable the AECB to implement on a timely and cost effective basis the systems and methods required to support the new Long Range Plan for Information Management.

Proponent	IMS
Technical Advisor/Evaluator	IMS (W. Goodwin)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	2

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$10k	$70k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

9.103.1	$73000	$77000	$0			$150000
9.103.2	$0	$0	$120000			$120000

9.106.2 A Review of the UCP System

A project is proposed which would take the results of a previous contract which described and documented the AECB Classification System and would propose changes to the system. The changes would ensure that the system is, in principle, fair and systematic and has no built-in biases against women or minority groups.

The AECB is in the process of reviewing the Classification System, to ensure the system conforms to government standards and regulations, particularly as it relates to salary equity.

The results of the contract would be used in the on-going evaluation and development of the AECB Personnel Classification System.

Proponent	AD
Technical Advisor/Evaluator	AD (D.B. Sinden)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$15k	$35k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

9.106.1	$0	$16000	$0			$16000

9.116.1 The Concept of "Environment" in a Legal Context

It is proposed to fund a workshop to examine the concept of "environment" in relation to dicussions of damage due to industrial accidents and compensation. The workshop would consider whether the concept of "damage to the environment" is contained in the current legal concept of "damage to property and persons" or is a distinct entity.

The Nuclear Liability Act is intended to address, inter alia, the issue of compensation following damage to persons or property. The use of the term "environment" in such discussions appears to be used by different authors in different shades of meaning. An examination of the concept is required to determine whether the term "environment" is contained in, or equivalent to, "property and persons".

The results of the workshop would be used in deliberations relating to international conventions which address the liability issue and in national discussions on the protection of Canadians.

Proponent	Secretariat
Technical Advisor/Evaluator	Secretariat (J. McManus)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

9.117.1 Development of a Security Program for EDP at the AECB

It is proposed to fund a contract to produce EDP security policy and procedures appropriate to the needs of the AECB which are also consistent with and meet the legal and policy requirements of the Government of Canada. The contract would also recommend essential systems and equipment required to implement EDP security policies and procedures.

The RCMP, as required by mandate, recently conducted an audit of EDP security at the AECB. The inspection covered security-related aspects of the data processing operations, including organizational, administrative, personnel, physical and environmental, communications, hardward, applications and systems software, operations, and small systems. Subsequently, the AECB received a detailed report on the findings of the Security Evaluation and Inspection Team. Seventy-three recommendations, which are considered mandatory to ensure compliance with government security standards, are identified in the report. The AECB must respond within six months advising its plan and schedule for meeting requirements. The AECB does not have the expertise available to dedicate to the development activity.

The results of this project will allow the AECB to meet its obligations under the laws and policies of the Government of Canada respecting security and privacy. It is anticipated that once policies, procedures and systems are established, the security program can be maintained using AECB resources. The net benefit to the AECB will be increased confidence that its information assets are protected and available to staff when required.

Proponent	IMS
Technical Advisor/Evaluator	IMS (W. Goodwin)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	1

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

1990/91 CATEGORY 3 PROJECTS

1990/91 Research Projects
Category 3

2.089.2	Computer Software Quality Assurance (II)
2.101.1	Instrument Behaviour under Off-Normal Conditions
2.118.1	Behaviour of the Calandria Structure under Severe Conditions
2.133.1	Review of the SLOWPOKE Demonstration Reactor Control System
2.148.2	Molten Fuel/Moderator Interaction - Feasibility of Large Scale Tests
2.153.1	Computer Codes for Examining Circulation within Containment
2.155.1	Maintenance: Means and Methods
2.165.1	Studies of Stability and Related Issues for Small Reactors
2.170.1	Reliability of Electrical Motors under Accident Conditions
2.171.1	Portable Information Processing for Quality Assurance Audits
2.172.1	Computer-Based Safety Interlocks for Research Accelerators
2.177.2	Fuel Channel Refilling - Phase II
2.178.1	Critical Heat Flux Measurements in a Simulated Fuel Bundle
2.179.1	Performance of Steam Generator Emergency Water Injection
2.188.1	Tissue Equivalent Proportional Counter
2.190.1	Selection of Safety Significant Components of Nuclear Power Plants for Aging Assessments
2.192.1	Effect of Sheath Strain on Critical Heat Flux
2.193.1	Studies of Hydrogen Combustion Phenomena in CANDU Nuclear Power Plants
2.197.1	Fission Product Release at SLOWPOKE Reactors
2.198.1	Containment Performance under Severe Accidents
2.201.1	Review of Reactor Safety Characteristics - Phase I
2.208.1	Review of Darlington Probabilistic Safety Evaluation Events Involving Operating Action
2.213.1	Development of AECB Human Factors Guidelines
3.103.1	Absorbed Fraction of Ingested Uranium in Humans
3.128.1	A Search for An Active Fault - Miramichi Area, N.B.
3.135.2	Dosimetry of Organically Bound Tritium Derived from Diet
3.146.1	Canadian Atmospheric Stability Indicators
3.150.2	Effects of Radiation on Species Other than Man: Aquatic Organisms
3.153.1	Evaluation of Microdosimetric and Distributional Aspects of Tritium
3.154.1	Optimization of Doses between Atomic Radiation Workers and the Public
3.158.1	Geophysical Studies in Prince Edward County, Ontario
3.159.1	The Aspy Fault in Nova Scotia
4.112.1	Electrical Charge of Radioactive Aerosols in Uranium Mines
4.120.1	Sensitivity of Bronchial Epithelial Cells to Alpha Radiation
4.125.1	Exposure-Rate Effectiveness for the Induction of Lung Cancer
4.126.1	Computerized Mortality Search Procedures
4.130.1	Evaluation of Radon Daughter Exposures of Port Radium Miners
4.130.2	Mortality Analysis of Port Radium Uranium Miners (1950-1988)
5.115.1	Software Quality Assurance for Waste Disposal Models
5.129.1	Decommissioning of Open Pit Mines - Literature Survey
5.137.1	Study of Radionuclides in the Lichen-Caribou-Man Food Chain

6.115.1	Development of an Extremity Dosimeter: Ring Dosimeter
7.093.2	Epidemiology of Lung Cancer in a Canadian Mining Community
7.116.1	Cancer Morbidity Follow-Up Feasibility Study
7.117.1	Hospital Record-Keeping System for Epidemiological Studies
7.126.1	Use of An Employee Identification Questionnaire and Guide
7.127.1	Dose Response of Human Lymphocytes to Radiation and Chemical Carcinogens
7.128.1	The Relative Impact of Radiation-Induced Genetic Disorders
7.132.1	Computerized Format for Pooling Radiation Exposure Records
7.133.1	Bone Cancer from Radionuclide Intake
7.134.1	Threshold Effect of CNS Defects Due to In Utero Exposure
7.142.1	Mortality Analysis of the Fluorspar Miners from 1985-1988
7.143.1	Canadian Cancer Data Base
7.144.1	Development of an "Index of Harm" for Canadian Workers
7.145.1	Screening Breast Cancer Patients for A-T Heterozygosity
7.148.1	In-Vitro Study of the Combined Effects of Radiation and Chemical Substances
7.149.1	Biological Dosimetry
7.150.1	Site-Specific Assay for Mutation in Human Cells
8.103.1	Testing of Foam Used in Packaging for Shock and Thermal Absorbency
9.102.1	Review of Crisis Management Methods

2.089.2 Computer Software Quality Assurance (II)

It is proposed to obtain consulting services concerning quality assurance for analytical software used in nuclear power reactor engineering. The consultant would review the types of analytical software to be covered by the proposed Canadian Standards Association (CSA) quality assurance standard in the N286 series and recommend to AECB staff appropriate quality assurance approaches and procedures for the design, development and maintenance of such software.

AECB staff are participating in a CSA committee to establish a quality assurance standard in the N286 nuclear series applicable to analytical software such as codes to simulate thermohydraulic processes or software tools to perform Computer Aided Design. This has been recently identified as an area where the AECB should increase its involvement. The AECB does not have sufficient in-house expertise concerning software quality assurance and software engineering, hence the need for external assistance.

This activity will provide independent advice to enable the AECB to contribute more effectively to the N286 analytical software committee.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (D. Scrimger)
Project Manager	D.E. Connelly
Review Panel	12
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$50k	$0k	$0k	$50k
Earlier Directly-Related Contracts and Funding:						
2.089.1	$20000	$0	$0			$20000

2.101.1 Instrument Behaviour under Off-Normal Conditions

It is proposed to conduct a study on the behaviour, during and after selected hypothetical severe accident conditions, of instruments used in CANDU reactors. Emphasis would be placed on the accuracy of thermocouples, pressure transducers and flow meters during and after being forced to operate at the extremes of, or outside, their scales.

Information on instrument behaviour during and after severe accident conditions is scarce. This work, therefore, would generate new knowledge necessary to improve the understanding of instrument readings during and after abnormal events.

The results of this study would be used in assessing licensee assumptions and interpolations regarding accident scenarios described by instrument-reading records.

Proponent	SSS, SED
Technical Advisor/Evaluator	SED (B. Finigan)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.118.1 Behaviour of the Calandria Structure under Severe Conditions

It is proposed to conduct an analytical study to investigate the survivability of the calandria structure under a hypothetical rapid increase in the temperature and pressure of the moderator.

It is uncertain how the calandria structure would eventually fail when subjected to a rapid increase in the temperature and pressure of the moderator. If the upper portion of the calandria (i.e. the reactivity mechanism deck) were to fail first this would result, in certain CANDU designs, in a breach of containment. Information is needed, therefore, to determine the consequences of such a hypothetical situation and then, if necessary, the measures which would be required to prevent or mitigate its consequences.

The results of this project would expand the knowledge base of AECB staff and augment their understanding of the behaviour of a CANDU reactor under a combination of hypothetical human errors and systems responses.

Proponent	SED, PRD
Technical Advisor/Evaluator	CQAD (B. Jarman)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$90k	$0k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

2.133.1 Review of the SLOWPOKE Demonstration Reactor Control System

It is proposed to review the control system for the SLOWPOKE Demonstration Reactor (SDR) to determine whether the proposed system configuration is appropriate for safe operation.

The dynamics of the SDR are characterized by a number of very long time constants, time delays and non-linearities. Therefore the design criteria and techniques commonly used for conventional nuclear reactor control systems may not be applicable.

This work will assist AECB staff in evaluating the ability of the design methods used for the SDR control and safety systems to take into account the full range of normal and abnormal operating conditions.

Proponent	SED
Technical Advisor/Evaluator	SED (B. Finigan)
Project Manager	D.E. Connelly
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

2.148.2 Molten Fuel/Moderator Interaction - Feasibility of Large Scale Tests

In participation with the Canadian nuclear industry, it is proposed to conduct a feasibility study to initiate a program of large scale experiments to investigate the potential for, and consequences of, a steam explosion arising from the interaction between the molten fuel and the moderator. The experimental set-up would be extensively instrumented (including provision for high speed optical and x-ray photography). The proposed work will cover conceptual design, instrument coverage, schedule and cost estimates.

Previous AECB research projects (Projects 84.1.30, 2.120.1 and 2.148.1) on this topic have indicated that the potential for steam explosion due to molten fuel/moderator interaction after a severe fuel channel flow blockage cannot be ruled out. Currently the AECB is sponsoring a small research program involving small scale experiments to provide basic understanding of the steam explosion phenomena. In the long term, large scale experiments will be required to develop an appropriate analytical tool to predict the occurrence and consequences of steam explosion. Recognizing, however, that the cost of such large scale experiments may be high, AECB staff is proposing to undertake this project jointly with the nuclear industry.

The findings of this project would provide information that would be used to determine the extent, cost and potential difficulties and/or merits of conducting the large scale tests.

Proponent	SED
Technical Advisor/Evaluator	SED (V.Q. Tang, C.W. Snoek)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

84.1.30	$55380	$0	$0		$55380
2.120.1	$50000	$0	$0		$50000
2.148.1	$17000	$19000	$0		$36000

2.153.1 Computer Codes for Examining Circulation within Containment

It is proposed to acquire the computer code COBRA-NC and convert it to work on one of the AECB computers. The code would be used to examine events such as LOCA and LOECC specifically to determine post-event hydrogen distribution within containment.

In safety analyses for LOCA and LOECC, the concentration of the hydrogen released inside the containment is assumed to be uniform. This assumption needs to be confirmed particularly when cooling fans are not credited. Hydrogen concentration distribution within the containment is an important parameter in taking the decision as to whether the ignitors should be initiated.

The outcome of this study would be used in evaluating the consequences of a hydrogen burn, and the appropriateness of the locations of the hydrogen ignitors within the containment.

Proponent	SED
Technical Advisor/Evaluator	SED (J. Khosla)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.155.1 Maintenance: Means and Methods

It is proposed to conduct a critical survey of the literature dealing with the methods, procedures and techniques of maintenance used to ensure the adequacy and to determine the status of equipment and components performance while in service. The study would cover nuclear and non-nuclear industries. The proposed survey would include detailed descriptions of various maintenance techniques such as preventive, corrective and reliability-centred maintenance.

According to independent assessments by the utilities and the AECB, inadequate maintenance is the primary cause of numerous significant events. A project that would critically review the current maintenance practices is proposed. Such a project would assist in establishing an understanding of the terminology used in Canadian utilities and those of other countries and in highlighting the differences in the basic understanding and use of the different means of maintenance.

The results would improve and enhance AECB staff understanding of the means and methods used for maintenance.

Proponent	SSS, CQAD, PRDB
Technical Advisor/Evaluator	CQAD (D. Vincent), PRDB (R. Ferch)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

2.165.1 Studies of Stability and Related Issues for Small Reactors

A project is proposed which survey the information available on instabilities in low-pressure, low-flow, natural circulation reactors. The project would focus on tools and techniques which would assist studies of potential instability regimes of these reactors.

There are indications that instability regimes exist for low-pressure natural circulation reactors. Most of the existing studies on instabilities in reactors are for high-pressure (BWR and PWR) designs. The AECB wishes to analyze the situation for proposed low-pressure designs under consideration by licensees. As a first step, the existing available information must be assessed.

The results of the project would assist AECB staff in reviewing safety documentation submitted to support licensing of small or research reactors. It would also provide generic information of importance for several other small reactor proposals, including the conceptual 10 MW heating reactor.

Proponent	OCD
Technical Advisor/Evaluator	OCD (P. French), SED (A.M.M. Aly)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

2.170.1 Reliability of Electrical Motors under Accident Conditions

It is proposed to determine the functional capability of naturally aged safety system electrical motor windings under accident and post-accident conditions, and to correlate the findings with the results of various non-destructive diagnostic measurements performed before and after the accident exposure. A heavy water coolant recovery motor was removed from NPD NGS containment area for this purpose. The proposed work would involve collection of data on the nature of the service environment, and laboratory tests and assessments at Ontario Hydro Research Division (OHRD).

Reliability of safety system electrical motors under expected accident and post-accident conditions is esential for the effective mitigation of accidents, should they occur. Present non-destructive diagnostic techniques have a limited capability for detecting the degradation of motor windings before failure and for predicting the remaining life for normal operating conditions. (Research work at OHRD sponsored by EPRI is addressing this limitation.) These diagnostic techniques are not able, as yet, to predict the performance of motor windings under accident and post-accident conditions.

The proposed work would enhance the development of effective condition monitoring techniques capable of detecting degradation before failure and of predicting remaining life under all anticipated service conditions, including accident and post-accident conditions. The results would improve the capability to assess the findings of diagnostic motor tests and would thus contribute to maintaining operational readiness of nuclear power plant safety systems.

Proponent	SSS, SED
Technical Advisor/Evaluator	SED (T. Leung)
Project Manager	J. Pachner
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$100k	$0k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

2.171.1 Portable Information Processing for Quality Assurance Audits

It is proposed to carry out a trial of a portable support system based on a laptop personal computer and standard off-the-shelf software to perform information processing during AECB quality assurance audits at Canadian nuclear generating stations. The contractor would review the user requirements, recommend appropriate hardware and software, and supply the recommended system on a rental basis for the duration of the trial.

During AECB quality assurance audits at Canadian nuclear generating stations, interim findings must be prepared under very tight schedules with limited staff. The audit process is very systematic hence it may be feasible to use existing laptop personal computer technology to alleviate the clerical workload and to improve the productivity of an audit team. The laptop system would also offer the possibility of integrating the preparation, field and corrective phases from an information processing viewpoint allowing efficient generation of reports and enabling more effective follow-up monitoring.

The results of the trial would be used to decide whether it would be worthwhile to use portable information processing systems more extensively in quality assurance audits at nuclear generating stations.

Proponent	CQAD
Technical Advisor/Evaluator	CQAD (M. Massicotte, D. Scrimger)
Project Manager	D.E. Connelly
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$10k	$0k	$0k	$10k

Earlier Directly-Related Contracts and Funding:

2.172.1 Computer-Based Safety Interlocks for Research Accelerators

It is proposed to carry out a study focused on the safety requirements for computer-based radiation interlock systems at research accelerator facilities.

Nuclear research requires accelerators that can produce particle beams of high energy and power leading to complex facilities that cannot be operated without intensive use of computers in the control and safety interlock systems. As a result, research accelerator facilities in Canada such as the Linear Accelerator Laboratory and TRIUMF are beginning to make significant use of computers to monitor or control their radiation interlock systems. Real-time computing systems are susceptible to unsafe failures due to undetected software faults and unforeseen combinations of hardware/software failures. Regulatory guides are required in this area for accelerators but the AECB does not have sufficient in-house resources to collate the necessary supporting information within the time frame imposed by the implementation of the new licence format and the rapid progress of the TRIUMF KAON-factor project.

The results of this work would assist AECB staff in preparing a regulatory basis and recommendations for regulatory actions concerning computer-based radiation interlock systems for research accelerators.

Proponent	OCD
Technical Advisor/Evaluator	OCD (A. Guilbaud, M. James)
Project Manager	D.E. Connelly
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$80k	$0k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

2.177.2 Fuel Channel Refilling - Phase II

It is proposed to review in detail the capabilities and limitations of the CATHENA code in simulating fuel channel refilling and rewetting phenomena, and recommend improvements, if necessary, to the numerical scheme and correlations.

In a current AECB research project (2.177.1) fuel channel refilling data are being reviewed, and a few experimental cases are being analyzed using the "as-is" CATHENA code. There is a need to extend the scope of the current project to review the CATHENA code capabilities and limitations in predicting the behaviour of a fuel channel refilling and rewetting under accident conditions. Accurate prediction of such behaviour is critical in predicting the fuel temperature which, in turn, influences the prediction of the fission product releases.

The findings of this project will provide AECB staff with further knowledge regarding two-fluid codes. It is anticipated that such codes will be used in licensing submissions in the very near future.

Proponent	SED
Technical Advisor/Evaluator	SED (V.Q. Tang)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$40k	$0k	$0k	$40k
Earlier Directly-Related Contracts and Funding:						
2.177.1	$0	$35920	$0			$35920

2.178.1 Critical Heat Flux Measurements in a Simulated Fuel Bundle

It is proposed to enter into a cost-sharing experimental program with AECL-CRNL in which an old 37-element cosine simulated fuel bundle would be rebuilt and its instrumentation repaired; the bundle would then be used to conduct a new series of critical heat flux (CHF) tests.

Several controversial issues are associated with the data obtained using this cosine bundle in 1982 and 1983. For example, there exists a 10% difference between the two data bases, and in determining the CHF values no allowance was made for the lack of comprehensive instrumentation coverage. These concerns were reinforced by a recent study done for the AECB (2.126.1) in which it was recommended that a new data base be obtained.

The results of the proposed test series would be used to: a) complement the available data base; b) reconcile the 10% difference between the 1982 and 1983 data bases; and c) assess the CHF correlation being used at present in the neutron overpower protection analysis for several CANDU stations.

Proponent	SED
Technical Advisor/Evaluator	SED (C. Snoek)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$75k	$200k	$125k	$400k

Earlier Directly-Related Contracts and Funding:

2.179.1 Performance of Steam Generator Emergency Water Injection

It is proposed to conduct an experimental study in which a section of the secondary side of a steam generator would be built to investigate phenomena associated with the emergency injection of water into the steam generator secondary side under accident conditions. The test section would be as close as possible in design to the actual geometry of the steam generators used in the Darlington NGS.

Licensing submissions addressing the effectiveness of the steam generator emergency cooling injection system have treated some of the crucial parameters as uncoupled. AECB staff believe that combined effects such as spray header water distribution, hot wall, and steam flow behaviour would dictate the overall performance of the steam generator emergency cooling system.

The results of this study should provide insight on particular aspects of cold water injection into the steam generator secondary side, and would be used to assess the validity of licensee submissions on this topic.

Proponent	SED
Technical Advisor/Evaluator	SED (J. Khosla)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$65k	$30k	$0k	$95k

Earlier Directly-Related Contracts and Funding:

2.188.1 Tissue Equivalent Proportional Counter

It is proposed to review the state of the art of tissue equivalent proportional counters, to evaluate the utility of these instruments that measure, directly, microdosimetric quantities (i.e. the energy deposited by single nuclear events in tissues), and to determine whether there is a need for such instruments for radiation protection purposes in Canada.

The biological effect produced by the traversal of a single nuclear particle through living tissues (an "event") is related to the discrete quantity of energy deposited in a small volume of approximately the size of a cell nucleus, a chromosome, or a gene. The event is expressed in terms of the energy deposited by the primary (impinging) particle or by the secondary emissions (delta rays) it created. The biological effect produced by a dose of radiation depends on the total energy deposited in the subject volume by the different events produced during the irradiation. The total quantity of energy deposited in that volume is subject to statistical fluctuations. Its mean value is referred to as the "dose". The amount of energy deposited by a single event is determined by, in addition to the nature of the event, the atomic composition of the tissue. Therefore, the discrete quantity of energy deposited by an event can be measured in a cavity filled with a gas of the same atomic compositions as the subject biological tissue, but with a much lower density. Under such conditions, a cavity of about one centimetre in diameter represents a sphere of biological material of one micrometre in diameter. Functioning as a proportional counter, such a cavity provides measurements that closely reflect what happens in living tissues. Tissue equivalent proportional counters can be used in a wide range of radiation exposure situations, especially in mixed gamma-neutron fields, to measure directly the dose received by exposed persons.

It is anticipated that this study will provide AECB staff with up-to-date information on the current state of development of tissue equivalent proportional counters, and will permit AECB staff to decide whether further development and use of such devices, for regulatory purposes, should be introduced in Canada.

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

2.190.1 Selection of Safety Significant Components of Nuclear Power Plants for Aging Assessments

As Phase 1 of a systematic nuclear reactor plant aging program, it is proposed to prepare structured lists of CANDU nuclear power plant safety-significant components of a) CANDU nuclear power plants and b) Canadian research reactors which are susceptible to aging degradation (the term "components" is used in a broad sense, meaning plant components, systems and structures.) The lists will be determined on the basis of CANDU and research reactor operating experience, expert knowledge, information from equipment qualification and other relevant external programs. Their structure would indicate priority according to which preliminary aging assessments would be conducted for the selected components in the scoping phase (Phase 2) of the program.

Aging degradation of NPP and research reactor components has the potential to adversely affect plant safety if it is not effectively managed. Nuclear reactor plants have thousands of components which experience aging effects to a greater or lesser degree. Because of limited resources, it is necessary to select and rank these components for which comprehensive evaluations of the impact of aging on plant safety should be conducted and effective aging management strategies and methods developed.

The results of this project would provide input for the scoping phase (Phase 2) of the nuclear reactor plant aging research program which constitutes the second step in the selection of plant components for the comprehensive aging assessments to be done in Phase 3 of the program. The program is designed with the intent to a) generate knowledge to identify and resolve emerging and unanticipated problems as they arise, and b) provide technical bases for licensing assessments and decisions relating to fitness for service of plant components and to operational safety of nuclear plants throughout their entire service life.

Proponent	SSS
Technical Advisor/Evaluator	DRR, SCD (P. French)
Project Manager	J. Pachner
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.192.1 Effect of Sheath Strain on Critical Heat Flux

It is proposed to investigate experimentally the effect of fuel sheath strain on critical heat flux (CHF). The work would involve the construction of a three-metre long, uniformly-heated bundle consisting of three elements (trefoil); the upstream half would have the nominal dimension of the 37-element CANDU fuel. The heater elements in the downstream half would be three percent larger in diameter. Critical heat flux experiments would then be conducted for both geometries (nominal and three percent larger) by reversing the flow direction. (Uniform heating implies that dryout would occur at the end of the channel and this would simplify the instrumentation.)

The Pickering Unit 1 fuel failure in November 1988 led Ontario Hydro and Chalk River Nuclear Laboratories to conduct detailed examinations of both failed and intact fuel. Results have shown that the intact fuel elements were strained by as much as two percent. However, the effect of fuel sheath strain on CHF has not been experimentally investigated. Although subchannel analysis can provide some information, experimental confirmation is required.

Experimental data on the relative reduction in CHF for strained fuel elements as compared to nominal fuel would assist AECB staff in estimating the reduction in the safety margins for CANDU stations containing strained fuel. Based on these results AECB staff could decided whether it is necessary to request the licensees to conduct similar tests with full-scale fuel channels.

Proponent	SED
Technical Advisor/Evaluator	SED
Project Manager	J. Pachner
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$75k	$0k	$0k	$75k

Earlier Directly-Related Contracts and Funding:

2.193.1 Studies of Hydrogen Combustion Phenomena in CANDU Nuclear Power Plants

It is proposed to study the phenomena relating to: a) hydrogen combustion in multiple jets (parallel and radially interacting) of hydrogen-steam mixtures; and b) the effect of radiation on the burning characteristics of hydrogen, e.g., flame velocity, transition to detonation, and detonation characteristics.

The above studies are proposed for the following reasons. a) In nuclear reactor containment, jets of hydrogen-air-steam mixtures are discharged through the openings in the air conditioning unit ducting at various locations inside the containment. These jets may be in the form of parallel jets (e.g. at the top of the feeder cabinet) or radially interacting (e.g. at the bottom of the steam generator or the heat transport pump). Jet interaction may create intense turbulence resulting in a very fast deflagration or deflagration-detonation transition. This may result in higher than predicted peak pressure in the vault or a local pressure pulse which may threaten the containment seals around the steam generator or the pump penetrations. This is intended to be a scoping study to determine experimentally the key parameters which may have a significant effect on the combustion processes (e.g. flame velocity, deflagration to detonation transition and the propagation of detonation), and to provide some quantitative measure of these effects. b) Radiation fields may result in significant amounts of free radicals which have the potential to affect combustion characteristics. This is intended to be an experimental scoping study to examine any significant effect that the free radicals (in composition and concentrations that may exist in the calandria cover gas space) may have on the combustion process.

The results of the work will enable AECB staff to assess the validity of the consequences predicted by the licensee of a hydrogen burn inside the CANDU containment and in the calandria.

Proponent	SED
Technical Advisor/Evaluator	SED (J.K. Khosla)
Project Manager	J. Pachner
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$50k	$0k	$100k

Earlier Directly-Related Contracts and Funding:

2.197.1 Fission Product Release at SLOWPOKE Reactors

The proposed work would measure fission products in the moderator/coolant of one or more operating SLOWPOKE reactors to determine the diffusion coefficients and why the coefficients have increased as the fuel has aged. The work would also confirm whether the release mechanism is actually diffusion or recoil.

The SLOWPOKE-2 facility has a radiation monitor just above the pool water. After several years of operation, the three oldest facilities have found that the radiation level may increase above the alarm setpoint during prolonged operation at high power. The reason for the increased level of radioactivity has been identified as an increase in the concentration of fission products in the container water. While this does not present a major hazard, the fact is that this change is unexpected and unexplained. Therefore, investigation of the matter is required.

The proposed work would provide information about SLOWPOKE fuel performance, which will be used to assess safety and licensing options for these reactors.

Proponent	SCD
Technical Advisor/Evaluator	SCD (P. French)
Project Manager	J. Pachner
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$0k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

2.198.1 Containment Performance under Severe Accidents

It is proposed to co-sponsor a research program which is being initiated to generate a database on concrete cracking, crack closure, leaking flows, and fission products attenuation. The lead organizations for this project are AECL, the University of Alberta, and Sandia National Laboratory. Multi-national participation will be solicited from other organizations.

The performance of containment concrete under severe accident conditions is the subject of recent research activities involving experiments and computer calculations. The results of Sandia's one-sixth scale containment test indicated that reclosure of cracks might prove to be an important factor in mitigating the consequences of accidents. Also, special effects experiments (AECB projects 84.1.1 and 2.147.1) indicate that the permeability of concrete to fission products is affected by the type of permeant (gas, liquid, aerosol, or mixtures), its size and chemical composition, and the fact that internal cracks in the concrete provide an easy leak path for the permeant. There is a need to confirm such observations in large-scale experiments in which typical reactor conditions and fission product chemicals would be used.

The information generated in this multi-national project would be used by AECB staff to assess the performance of concrete under severe accidents and under some high temperature transients.

Proponent	SSS, SED
Technical Advisor/Evaluator	SSS (A. Omar), SED (K. Asmis)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$100k	$100k	$220k

Earlier Directly-Related Contracts and Funding:

84.1.1	$94714.99	$0	$0		$94714.99
2.177.1	$0	$68704.75	$0		$68704.75

2.201.1 Review of Reactor Safety Characteristics - Phase I

It is proposed to perform a critical review of the general design of the CANDU-type reactor to identify any practical ways by which greater inherent or intrinsic safety could be incorporated. The review would also include a comparison with other types of advanced reactor concepts being considered worldwide to determine if there is any clear advantage in safety of one type over another. The scope of the review would be very broad inlcuding matters such as core design, station layout and the general design features of the systems, components and structures. The socio-economic impact of various alternatives would be analyzed to determine the practicality of each alternative. Initially a feasibility study will be done to design the whole review and to estimate the cost. The estimated price shown below is for the feasibility study only.

The current approaches to defence-in-depth for nuclear reactor safety rely extensively on active engineered components and systems, and on correct human actions to prevent , or to mitigate, the consequences of reactor accidents. The Three Mile Island and Chernobyl accidents have cast some doubt on the adequacy of current approaches to safety. Increased attention is now being given to examining reactor types and design features with greater inherent safety chraracteristics than current types and designs. However, such advances must be practical from the social and economic point of view, i.e., there must be a net benefit if possible advances result in an increase in cost.

The AECB would determine through the proposed independent review whether there are significant and practical opportunities to improve the safety of CANDU-type reactors and thereby determine whether or how far to pursue this matter with relevant licensees. If it is shown that there are clear safety advantages for some reactor types over others then the results might have an effect on reactor safety policy.

Proponent	SSS
Technical Advisor/Evaluator	SSS (J.W. Beare)
Project Manager	A. Omar
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$65k	$0k	$0k	$65k

Earlier Directly-Related Contracts and Funding:

2.208.1 Review of Darlington Probabilistic Safety Evaluation Events Involving Operating Action

It is proposed to conduct a review of the Darlington Probabilistic Safety Evaluation Study to identify those accidents where operator action or omission can significantly increase the severity of the consequences.

The test items in the AECB authorization examinations are based upon current operating and training documents. However, there is a need to evaluate completeness of failure modes and scenarios currently included in the examinations.

The proposed work would identify events which would be appropriate as base material for developing questions for AECB examinations and simulator testing scenarios.

Proponent	OCD
Technical Advisor/Evaluator	
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$120k	$0k	$0k	$120k

Earlier Directly-Related Contracts and Funding:

2.213.1 Development of AECB Human Factors Guidelines

It is proposed to fund a contract which would provide, through examination of the relevant literature, a basis for development of human factors standards, criteria and methodology applicable to the design, operation and maintenance of nuclear power plants. These should be prepared as annotated lists divided according to specific application areas within the plant (e.g. main control room displays, maintenance activities).

The AECB should provide guidance on the application of human factors to the design, operation and maintenance of NPPs. Current information and references will be incorporated into the standards to be established in regulatory guides.

The contract would provide information which would aid development of standards that should be met by licensees in the application of human factors knowledge to design, operation and maintenance of NPPs.

Proponent	SED
Technical Advisor/Evaluator	SED (L. Innes)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$40k	$0k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

3.103.1 Absorbed Fraction of Ingested Uranium in Humans

It is proposed to determine the absorbed fraction of ingested dietary uranium (from both food and drinking water) in persons living near certain nuclear facilities, by measuring the content of uranium in their diet and in their fecal and urinary excretions.

The currently used annual limit on intake (ALI) for uranium, by ingestion, is derived using a value of 0.05 for the absorbed fraction of ingested uranium. This value is known to have a number of uncertainties, and more work should be done to improve its accuracy.

The results of the study are expected to improve the value for the absorbed fraction and hence the estimate of the ALI (oral) for uranium.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy, M. Measures)
Project Manager	K.P. Ho
Review Panel	4
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$60k	$20k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

3.128.1 A Search for An Active Fault - Miramichi Area, N.B.

The Miramichi area was the site of several moderate earthquakes in 1982 (M5.0-5.7). A two-year program was undertaken in 1983-84 to try to locate the surface expression of the fault, movement along which was responsible for the earthquakes. In terms of finding the active fault it was unsuccessful, although valuable information on ambient stress and the rock response to the ambient stress was obtained. New data have become available which show a north-northwest trending lineament spatially related to many of the earthquake epicenters in the area. Moreover, computer generated, digitized imagery suggests that a plutonic body has been displaced across this structure, implying that the structure may be a fault.

It is proposed to excavate a trench, or a series of trenches, across a north-northwest trending lineament in the seismically active area of the Miramichi to determine whether or not there is evidence of surface rupture and displacement along it. This project has been endorsed by MAGNEC.

This study is proposed because if recent rupture and displacement are associated with this lineament it would imply that movement along this feature was probably responsible for the seismicity in the Miramichi. Furthermore, it would enable defining, at least locally, a major seismogenic source in eastern Canada.

Proponent	SSS
Technical Advisor/Evaluator	DRR (Z. Domaratzki), SSS (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$35k	$0k	$70k

Earlier Directly-Related Contracts and Funding:

84.4.7	$30000	$0	$0		$30000
84.4.8	$30000	$0	$0		$30000

3.135.2 Dosimetry of Organically Bound Tritium Derived from Diet

It is proposed to evaluate critically the existing metabolic models for the incorporation of organically bound tritium (OBT) contained in "normal" diets, and to establish whether these models can account for the enhanced levels of OBT obtained from the literature. A modified tritium uptake, retention, and dosimetry model will be developed if such a suitable model does not already exist.

Tritium from CANDU nuclear generating stations and other facilities and licensed activities is transported readily through the environment and can be incorporated into organic molecules whose metabolism in the body and dose distribution in the cell may differ markedly from that of tritiated water. The transfer of environmental tritium as OBT in food items and its radiological implications on man are reviewed in an AECB report, "Assessment of the Significance of Organically Bound Tritium in Environmental Materials" ((INFO-0283). That report asserts that since OBT to HTO ratios of greater than unity were observed in food items at environmental tritium levels, the dose estimate based on the ICRP model for intakes of tritiated water may not be appropriate. It further recommended that reliable metabolic models should be developed for estimating the internal dose from the dietary intake of food items containing organically bound tritium.

The results of this work will complement the experimental measurements of OBT in Canadian food items taken in another AECB research project (3.135.1) and provide AECB staff with information on the appropriateness of metabolic models used in tritium dose estimation made by its licensees. (The AECB is expecting to seek joint funding of this project with AECL and provincial utilities.)

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath, R. Chatterjee)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

3.135.1	$75000	$0	$0			$75000

3.146.1 Canadian Atmospheric Stability Indicators

It is proposed to fund a study to analyze data collected over several years using statistical techniques and theories of atmospheric turbulence in order to identify relationships between the direct and indirect indicators of atmospheric stability.

In order to calculate the concentrations of radioactivity in the air following a release from a nuclear facility, the stability of the atmosphere must be specified. Since atmospheric turbulence is difficult to measure, this is normally done indirectly through simple indicators that are known to be correlated with direct turbulence estimates. (Temperature gradients as indirect turbulence indicators, are frequently used in accident analysis and emergency response programs.) However, these correlations between the direct and indirect indicators were developed in England and in the southern U.S. and are inappropriate for the Canadian climate, particularly in the winter when the ground is snow covered.

The results of the project are intended to provide a method to deduce atmospheric stability from simple, routine meteorological measurements for the Canadian climate, and so improve the AECB's confidence in predicted atmospheric radionuclide concentrations following releases from nuclear facilities.

Proponent	SED, RPD, HES
Technical Advisor/Evaluator	SED (L. Truong), RPD (C. Letourneau)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$45k	$0k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

3.150.2 Effects of Radiation on Species Other than Man: Aquatic Organisms

It is proposed to determine, in the laboratory, whether the deformities observed in a large number of insect larvae (chironomids) in Port Hope Harbour are due to radiation.

Radium and uranium refining operations have contaminated the sediments of Port Hope Harbour with radionuclides of the U-238 and Th-232 decay chains. The sediments are also contaminated with other heavy metals such as Fe, Cu, Pb and Ni. In a recent study, it was found that 83% of the chironomus species present in the more heavily polluted inner harbour had deformed mouth parts, whereas only 14% of the chironomids in the outer harbour were deformed. The authors suggested that radiation may have induced these deformities. The proposed laboratory study will determine whether the effects observed are indeed caused by radiation.

It is anticipated that the results of this study will determine whether chronomids could serve as an efficient biological indicator of contamination of the environment by radioactive substances, and provide additional insight into the effects of radiation on species other than man.

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Létourneau, M. Measures)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

3.153.1 Evaluation of Microdosimetric and Distributional Aspects of Tritium

It is proposed to review and evaluate the existing literature on the microdosimetry of tritium. This review will focus on the relationship between distributional effects, both within the cell and within the organ, and radiation dose. It will also assess whether microdosimetric considerations support a quality factor other than unity for tritium which has been incorporated into cells of tissues and organs.

The conventional methods for calculating the radiation dose delivered to human organs by tritium assumes that the dose to all cells of an organ is uniform. A basic requirement for the validity of this assumption is the fairly homogeneous distribution of tritium and its emitted energy, both among tissues and organs, and within cells, of the body. However, some recent studies indicate that tritium-labelled organic compounds ("organically bound tritium") concentrate in specific organs and tissues of the body. Hence tritium may be retained in an organically bound, non-uniformly distributed manner in some cells. Doses to such cells and organs containing them may be significantly higher than would be the case for an homogeneous distribution of tritium.

It is anticipated that the results of this critical review will help AECB staff to evaluate the significance of doses from tritium which is non-uniformly distributed within the body, and will provide additional information relevant to the quality factor for tritium. The results of this project, in concert with those of 3.135.1 and 3.135.2, will aid AECB staff to assess the tritium dosimetry programs of licensees.

Proponent	RPD
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

3.154.1 Optimization of Doses between Atomic Radiation Workers and the Public

It is proposed to study the impact, within the framework of the ALARA principle, on members of the public resulting from a dose reduction to atomic radiation workers in a nuclear facility.

In operations such as mining, one of the main controls that is used to reduce radiation exposure is to increase the ventilation in the work areas. This in turn, might cause the radioactive emissions to increase and to be dispersed into the environment which might subsequently result in the public receiving a greater dose of radiation. It is therefore proposed that a study be undertaken to determine what impact the reduction of dose to workers in a nuclear facility will have on the dose to members of the public.

It is anticipated that this study will help AECB staff to assess the ALARA submissions from its licensees.

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Létourneau, S.H. Ching)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$25k	$25k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

3.158.1 Geophysical Studies in Prince Edward County, Ontario

It is proposed to undertake land-based geophysical surveys in Prince Edward County, Ontario, in order to trace some linear features identified in the bays and inlets off Lake Ontario, as well as a Jurassic-age dike which has been sheared by strike-slip movements. This project has been endorsed by MAGNEC.

This study is proposed because: a) marine investigations revealed signatures suggesting the presence of linear structures which may be faults, and b) it is necessary to know whether or not the dike may be displaced.

It is anticipated that the results of this study will add substantial information to an already enriched information base from Prince Edward County. Furthermore, this work should nicely complement the geological investigations and, except for possible surprises or specialized studies such as dating fault- and fracture-filling minerals or undertaking seismic monitoring, should terminate the efforts in Prince Edward County.

Proponent	SSS
Technical Advisor/Evaluator	DRR (Z. Domaratzki), SSS (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$10k	$10k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

3.131.1	$25000	$0	$0		$25000
3.131.2	$0	$25000	$0		$25000

3.159.1 The Aspy Fault in Nova Scotia

The Aspy Fault, located at the north end of Cape Breton Island, vertically displaces a 100,000-year old marine terrace by about 16m. However, it is not known whether the total displacement is the result of a very few major tectonic episodes, which may have resulted in large magnitude earthquakes, or several smaller scale movements attendant, perhaps, on glacial isostatic rebound. This project has been endorsed by MAGNEC.

It is proposed to use aerial photographs and other remotely sensed imagery to locate exposures of bedrock and unconsolidated material along the inland extension of the Aspy Fault. Exposures most likely to reveal evidence of the fault will be examined in the field in order to try to determine the amount of movement that has occurred within a particular time frame by measuring increments of displacement across the fault which cut Quaternary sediments.

It is anticipated that the results of this study, if successful, should show whether or not the total displacement, seen across the fault in Aspy Bay, is the result of few or many episodes of displacement. If few, the Aspy Fault would be regarded as potentially seismogenic. The type of information to come from this study should be useful in analyzing the seismic potential of faults, with similar charactertistcs, relevant to current or future nuclear facilities.

Proponent	SSS
Technical Advisor/Evaluator	DRR (Z. Domaratzki), SSS (J.L. Wallach)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$30k	$30k	$0k	$60k

Earlier Directly-Related Contracts and Funding:

3.130.1	$0	$15000	$0			$15000

4.112.1 Electrical Charge of Radioactive Aerosols in Uranium Mines

It is proposed to measure the fraction of positively and negatively charged aerosol particles carrying radon and thoron daughters, to determine the number of elementary charges carried by individual charged particles, and to relate these parameters to the ionization conditions and carrier aerosol parameters that prevail in underground uranium mine atmospheres.

The radiation dose delivered to the lung from inhaled radon and thoron daughters depends upon the deposition of these radioactive particles in the respiratory tract, which in turn depends on the size distribution and electrical charge of these particles. The aerosol size distribution itself is governed in part by the electrostatic attraction between ultrafine radon and thoron daughters and carrier aerosol particles generated by mining activities and diesel engines. Owing to the ionization induced by relatively large concentrations of alpha radiation emitters, the consequent phenomena (collectively referred to as "atmospheric electricity") play an important role in shaping the resulting radioactive aerosol actually inhaled by miners. To date, no study has been carried out in Canadian mines to determine the electrical properties of airborne radon and thoron daughters.

It is anticipated that the findings of this study will, for the first time, bring information to AECB staff on the electrical state of radioactive aerosols in mines. This information may also be used in interpreting monitoring and dosimetry data and may serve to complement the computer modelling of mine atmospheres.

Proponent	HES, EMR (J. Bigu)
Technical Advisor/Evaluator	RPD (S. Ching)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$30k	$20k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

4.125.1 Exposure-Rate Effectiveness for the Induction of Lung Cancer

It is proposed to investigate the exposure-rate effectiveness for the induction of lung cancers among miners exposed to radon daughters. The exposure data for Ontario uranium miners, Newfoundland fluorspar miners, Beaverlodge and Port Radium miners, and for the U.S. and Swedish miners will be analyzed statistically to derive a relationship between the induction of lung cancers and the exposure rate (in working level month/year) at which the miners were exposed to radon daughters at their respective work places.

Animal studies have shown that exposure to radon daughters at high exposure rates are less effective in inducing lung cancer (below the onset of cell killing effects) than the corresponding exposures delivered at low exposure rates. It is prudent to investigate this phenomenon in human populations occupationally exposed to radon daughters. Since radon daughter concentrations in the underground uranium and fluorspar (St. Lawrence, Newfoundland) mines during the early years of mining were substantially higher than those of today's miners, those early miners were exposed at higher exposure rates. To date, no comprehensive analyses of the exposure data of the uranium miners in Canada and in the U.S., of fluorspar miners in Newfoundland, and of iron ore miners in Sweden, have been performed to facilitate a better understanding of the exposure-rate effectiveness for the induction of lung cancer among miners exposed to radon daughters.

The results of this study will improve our understanding of the exposure rate effectiveness and risk estimates for the induction of lung cancer following exposure to radon daughters.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$10k	$0k	$45k

Earlier Directly-Related Contracts and Funding:

4.120.1 Sensitivity of Bronchial Epithelial Cells to Alpha Radiation

It is proposed to investigate, by means of a search of the literature (human and animal data) and discussions with researchers currently active in the field, the sensitivities of bronchial epithelial cells to alpha radiation of energies of 8 MeV and below. The investigation will focus on the production of chromosome aberrations in cells and on induction of lung cancer.

This study is proposed because the process of inducing lung cancer in humans by exposure to alpha radiation (such as is believed to occur in uranium miners) is not well understood. The cells of the bronchial epithelium which, upon absorption of alpha energy, initiate the development of lung cancer have not been identified with certainty.

It is anticipated that the findings of this study will provide information that is pertinent to understanding the mechanism of lung cancer induction by radiation.

Proponent	RPD, HES, Sask. Dept. of Human Resources, Labour & Employment
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

4.121.1	$89000	$28000	$0			$117000

4.126.1 Computerized Mortality Search Procedures

It is proposed to fund the preparation of a technical report which will document the structure of the files, methodology, flow of information, and data quality control checks used in the 1986 mortality search update of the Ontario miners study.

This project is proposed because, in the past decade, computer linkage methodologies have been improved greatly and new procedures have been developed. Weights have been derived for the parameters to be matched, and more links have been generated by using intermediate files to facilitate the linkage. Because updates to the mortality data bases are being proposed to be done on a five-year basis, it would be a logical step to document the methods being used, to facilitate ease of future updates. The data from these studies are being used extensively, internationally, to improve the risk estimates for radiation-induced lung cancers.

The results of the technical report prepared could prove valuable for persons involved in any pooling of data on radiation workers. Recommendations for future improvements on record linkage will be made.

Proponent	RPD, HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$25k	$0k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

4.130.1 Evaluation of Radon Daughter Exposures of Port Radium Miners

It is proposed to fund the evaluation of the radon daughter exposures (in working level months (WLM)) received by nearly 2100 miners who worked at the uranium mines in Port Radium in the Northwest Territories for the period from 1930 to 1960, and who may have had previous exposures to radon daughters in other mines.

The risk estimate for lung cancer obtained from the previous study of Port Radium uranium miners, by Howe et al., was 0.27% per WLM. This value is at the lower end of the range of relative risk estimates (0.3 to 3.3 % per WLM) reported for other Canadian and international studies (Ontario uranium miners: 1.3% per WLM, Newfoundland fluorspar miners: 0.9% per WLM, Beaverlodge uranium miners: 3.3% per WLM, U.S. Colorado uranium miners: 0.8% per WLM, Czechoslovakian uranium miners: 1.8% per WLM, and Swedish iron miners: 1.4% per WLM). Among the Canadian studies, exposures received by both the Ontario uranium miners and Newfoundland fluorspar miners were re-evaluated using improved techniques and additional information on exposure histories, which resulted in better agreement between their respective revised risk estimates (as stated above). The exposures received by the Beaverlodge uranium miners are being re-evaluated (project 4.118.1) and the results will be used in an updated mortality analysis (4.118.2). Therefore, it is important to re-evaluate the exposures of individual miners who worked in the uranium mines in Port Radium, taking exposures received by them in other mines into account as well as their work histories, and design characteristics of the mines.

It is anticipated that the results of this study will give the AECB improved exposure estimates for Port Radium uranium miners. These estimates will be used in an updated mortality analysis of Port Radium uranium miners (following project 4.130.2) to derive improved risk estimated for lung cancer due to exposure to radon daughters.

Proponent	RPD, UFD, HES
Technical Advisor/Evaluator	RPD (M. Measures, S. Ching), UFD (D. Corkill)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$55k	$20k	$0k	$75k

Earlier Directly-Related Contracts and Funding:

4.130.2 Mortality Analysis of Port Radium Uranium Miners (1950-1988)

It is proposed to update the mortality analysis of the uranium miners in Port Radium, in the Northwest Territories, for the period from 1950 to 1988, using computerized linkage to the Canadian Mortality Data Base at Statistics Canada. Additionally, the revised exposure estimates obtained from the previous project (4.130.1) will be used with the mortality data to obtain revised risk estimates for lung cancer per unit exposure to radon daughters.

The risk estimate for lung cancer obtained from the previous mortality analysis of the Port Radium uranium miners is known to have a number of uncertainties, including the uncertainty in its exposure estimates. Furthermore, since the previous analysis, several additional years of mortality data have been accumulated by the Canadian Mortality Data Base. It is therefore necessary to re-evaluate the risk of lung cancer per unit exposure to radon daughters, using both the revised exposure information (4.130.1) and the additional mortality data to the end of 1988.

It is anticipated that the results of this study will improve the risk estimates for lung cancer due to exposure to radon daughters. (This is expected to be a joint study with the National Cancer Institute of Canada (NCIC) on an equal cost-sharing basis.)

Proponent	RPD, UFD, HES, NCIC (G. Howe)
Technical Advisor/Evaluator	RPD (C. Pomroy), UFD (D. Corkill)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$10k	$40k	$15k	$65k

Earlier Directly-Related Contracts and Funding:

4.130.1	$55000	$0	$0			$55000

5.115.1 Software Quality Assurance for Waste Disposal Models

It is proposed to survey the latest developments in quality assurance programs for software as applied to modelling. The survey would identify the best applicable methods for assuring the quality of software systems to be applied to nuclear waste disposal.

AECB staff will be required to assess licence submissions concerning the predicted performance of existing and proposed nuclear waste disposal facilities. Some of these performance predictions will be generated by software modelling packages currently under development by industry and government agencies. Confidence that all of the requirements associated with model design, development and testing have been identified and implemented, is dependent on the effectiveness of the software quality assurance programme.

The results of the survey will assist AECB staff in assessing the effectiveness of the quality assurance programme to be applied to a particular model and hence the degree of confidence associated with how the model will perform.

Proponent	CQAD, WMD
Technical Advisor/Evaluator	CQAD (D. Scrimger), WMD (P. Flavelle)
Project Manager	D.E. Connelly
Review Panel	12
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

5.129.1 Decommissioning of Open Pit Mines - Literature Survey

It is proposed to conduct a literature survey of regulatory requirements for the decommissioning of all open pit mines, irrespective of the exploited mineral resource. The study would therefore include both uraniferous and non-uraniferous deposits.

This study is proposed because there are several open pit mines in Saskatchewan that will be decommissioned within the next year or two. These mines contain arsenic and nickel as well as uranium and it is desired to know what has been required by regulatory bodies and what has been done to effect decommissioning in the past.

It is anticipated that the results will be used to aid the AECB in assessing approaches and strategies for decommissioning proposed by licensees.

Proponent	WMD
Technical Advisor/Evaluator	WMD (R. Maloney)
Project Manager	J.L. Wallach
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$30k	$0k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

5.137.1 Study of Radionuclides in the Lichen-Caribou-Man Food Chain

It is proposed to study the transfer of uranium series radionuclides polonium-210 and lead-210 in the lichen-caribou-man food chain, in northern Saskatchewan and the Northwest Territories, in order to determine transfer coefficients and bio-concentration factors for these two radionuclides in this environmental pathway.

One of the areas of uncertainty regarding the impact of uranium mining is the distribution of radionuclides, in the terrestrial environment, and the subsequent movement of these radionuclides in food chains leading to man. This is of particular concern in the subarctic and arctic, where the deposition of contaminants can be widespread and the concentration in food chains significant. This possibly significant accumulation may be due to the simplicity of arctic food chains, the longevity of vital parts of the food chain and the efficiency of accumulation of contaminants by vital parts of the food chain (particularly the lichens). There has been little work on uranium series radionuclides in these climatic regions. Because of increased mining developments in Saskatchewan, and a proposed uranium mine in the Northwest Territories near Baker Lake, the question of the significance of the terrestrial pathway for uranium series radionuclides to man is current and pressing. Therefore it is proposed to study transfer and bio-concentrations of polonium-210 and lead-210 in the lichen-caribou-man pathway. Polonium is chosen because of its radiotoxicity and propensity to concentrate in soft tissue, and lead-210, to establish the ratio between the two radionuclides.

It is anticipated that the results of this study will help AECB staff to evaluate the submissions on impact to the environment and to man prepared by uranium mining licensees. Joint funding will be sought from other interested agencies such as Environment Canada and the Saskatchewan Research Council.

Proponent	RPD, WMD
Technical Advisor/Evaluator	RPD (C. Létourneau), WMD (B. Zgola)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$70k	$20k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

6.115.1 Development of an Extremity Dosimeter: Ring Dosimeter

It is proposed to develop an extremity dosimeter ring using 5 mg/sqcm thick skin dosimeters which are commercially available in China. These skin dosimeters are referred to as GR-200F, composed of the compound LiF (Mg, Cu, P). The work will consist of type-testing the dosimeter for a) batch homogeneity; b) reproducibility; c) linearity; d) detection threshold; e) stability; f) photon/beta-ray energy dependence; g) angular dependence; h) residue; and i) effects of exposure to light. In addition, a holder-ring will be developed that uses a thin window to allow for the detection of low energy beta-rays (end-point energy < 250 keV). The holder-ring will be strong, light in weight, and comfortable to wear. It will remain in the proper orientation when worn, and not interfere with the manual dexterity of the user.

This project is proposed because a GR-200F skin dosimeter will be far more sensitive to low energy beta-rays than the dosimeters currently used in most Canadian dosimetry services. However, it is necessary to type-test the GR-200F skin dosimeters for quality assurance purposes, and develop a holder-ring that will take full advantage of the dosimeter's sensitivity to low energy beta-rays.

It is anticipated that the results of this project will be useful to AECB staff in setting acceptance criteria for extremity dosimeters, which are not currently included in the consultation document C-106. (The study is to be jointly funded by the AECB and AECL on an equal cost-sharing basis: AECB $43k, AECL $43k)

Proponent	RPD
Technical Advisor/Evaluator	RPD (G. Poirier)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$43k	$0k	$0k	$43k

Earlier Directly-Related Contracts and Funding:

7.093.2 Epidemiology of Lung Cancer in a Canadian Mining Community

It is proposed to resume a case-control epidemiology study of lung cancer mortality in Canadian mining communities, initiated in Timmins, Ontario, in 1984 (project 7.093.1).

The original study was undertaken in order to identify the hazards responsible for an elevated (relative to the provincial average) incidence of lung cancer in the community. The main factor of risk being studied is long-term exposure to indoor radon daughters. The preliminary analysis of the earlier study showed a lack of correlation between 90 cases of lung cancer and domestic exposure to radon daughters. It is now proposed to study an additional 75 cases of lung cancer, and to double the number of controls for each case. The residential history of cases and controls will be traced back as far as possible.

It is expected that the results of this study will be used to reduce uncertainties in risk estimates for radon daughter-induced lung cancers, especially at low exposures. (This study will be co-funded by the Department of National Health and Welfare at a level of approximately $30k per year.)

Proponent	RPD, HES, NHW (D. Wigle)
Technical Advisor/Evaluator	RPD (S. Ching, C. Pomroy)
Project Manager	P. Duport
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$45k	$45k	$30k	$120k

Earlier Directly-Related Contracts and Funding:

7.093.1	$78000	$0	$0			$78000

7.116.1 Cancer Morbidity Follow-Up Feasibility Study

It is proposed to determine the feasibility of using computerized record linkage with national cancer incidence data available in Canada for individual medical follow-up studies by attempting to link the National Dose Registry with the Alberta Cancer Registry and to determine any association between occupational radiation exposure levels and cancer incidence. This would be of particular assistance in developing the potential future use of the Canadian Cancer Data Base.

This feasibility study is proposed because cancer data will greatly assist the AECB in determining whether any excessive health effects or risks exist due to exposure to certain potentially hazardous environmental, occupational or other factors. This information will both complement and supplement mortality data available through the Canadian Mortality Data Base by providing a more sensitive measure (than mortality data alone) of the differences in risk from exposure to potentially hazardous environmental, occupational or other factors and a possible earlier detection of any potential health hazard. It will allow for earlier preventive measures to be introduced in the workplace for current as well as future employees.

It is anticipated that this study will provide the AECB with: (i) the ability to draw upon more cancer data from Canadian sources; and (ii) the opportunity to detect the occurrence of any non-fatal or rare cancers. In addition, it will assist the AECB in identifying areas of occupational, environmental, and other health risks for the general public. It will aid the AECB in its regulatory activity, and will also help in providing information for the assessment of exposures and occupational hygiene practices.

Proponent	HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$30k	$20k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

7.117.1 Hospital Record-Keeping System for Epidemiological Studies

It is proposed to conduct a feasibility study to modify hospital record-keeping systems to facilitate inexpensive case-control epidemiological studies of radiation-induced cancers.

Case-control studies of radiation-induced cancer can be conducted inexpensively using hospital records. However, the record-keeping systems in Canadian hospitals are not currently in a format to facilitate such studies.

It is anticipated that the results of the study will determine the feasibility of modifying hospital record-keeping systems to facilitate epidemiological studies. If the modification is feasible, several epidemiological studies of radiation-induced health effects can be conducted inexpensively to improve the corresponding risk estimates.

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	2
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$30k	$0k	$50k

Earlier Directly-Related Contracts and Funding:

7.126.1 Use of An Employee Identification Questionnaire and Guide

It is proposed to fund a project which is intended to promote the use of the employee identification questionnaire and the user guide developed and tested in the project entitled "Standardization of Individual Identifying Information for Health Record Keeping Methodology" (7.108.1). With information collected in Phase II (of 7.108.1) which identifies the potential users for this questionnaire, methods will be selected for advising Canadian companies and agencies, as well as international agencies and committees with occupational health record keeping requirements, of the questionnaire with a view to encouraging its use to improve the possibilities as well as decrease the costs of long term medical follow-up.

This project is proposed, in particular, because the derived information is intended to be targeted at AECB licensees who are required to implement and maintain health record systems and who supply information on radiation doses to the National Dose Registry. It is also of practical use for facilitating follow-up after any emergency or accident e.g. Chalk River clean-up, Chernobyl, PCB spill, and for standardization of records for international collaborative studies, e.g., Eldorado Nuclear Limited, Ontario Miners Mortality Study, or for review by international bodies, such as the ICRP and the BEIR Committee.

It is anticipated that the results of the study will facilitate and encourage adequate on-going individual record keeping for the preparation of current and past employee nominal rolls as well as for special studies. In addition, it may form the basis of an unambiguous identification of the individual in conjunction with the collection of radiological and non-radiological exposure histories and work histories. These will allow for subsequent follow-up, by the AECB, of health outcomes (mortality, morbidity, and genetic effects), and will be of use for reporting purposes to registries (dose, exposure and disease), and for other legislative or regulatory requirements. (This is to be a joint study with Statistics Canada.)

Proponent	HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$15k	$0k	$0k	$15k

Earlier Directly-Related Contracts and Funding:

7.108.1	$80000	$0	$0			$80000

7.127.1 Dose Response of Human Lymphocytes to Radiation and Chemical Carcinogens

It is proposed to investigate the feasibility of using a flow cytometry method for measuring radiation damage in fresh (recently extracted) human lymphocytes, and to measure the damage produced by a combined exposure to radiation, delivered at doses in the occupational range, and to chemical carcinogens.

This project is proposed because currently there is uncertainty as to whether radiation and chemical insults act synergistically, independently, or whether the chemical carcinogens influence a cell's response to radiation insult. This project is intended to be an appropriate follow-on to 7.107.1, "A Feasibility Study on the Identification and Determination of Exposure Levels of Non-Radiological Carcinogenic Substances at Canadian Nuclear Facilities", as it will provide experimental evidence of synergism or lack thereof.

It is anticipated that the findings of this study will assist AECB staff in quantifying the modifying influences of chemical carcinogens on the responses of workers to occupational radiation exposure. (This project is proposed to be funded jointly with AECL. AECL and the AECB will each contribute 50% of the cost of the project for a total of $146K.)

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$48k	$25k	$0k	$73k

Earlier Directly-Related Contracts and Funding:

7.107.1	$46000	$0	$0			$46000

7.128.1 The Relative Impact of Radiation-Induced Genetic Disorders

It is proposed to fund a study to determine the relative impact of different types of radiation-induced serious genetic disorders in terms of their respective loss of years of life expectancy by linking the B.C. Health Surveillance Registry Records with the Canadian Mortality Data Base.

The study is proposed because the relative impact of different types of serious genetic disorders can only be compared on a common scale, such as in terms of their respective loss of years of life expectancy. To date, no comprehensive study has been done to derive the relationship between different types of genetic disorders and their respective loss of years of life expectancy in the Canadian context. The data base at the B.C. Health Surveillance Registry is considered to be a leading source in North America for such a complex analysis. Initiation of this study is awaiting the review of 7.109.1.

It is anticipated that the results of the study will enable the AECB to compare, on a common scale, the relative impact of different types of radiation-induced genetic disorders. (This is proposed to be a joint study with B.C. Ministry of Health and Statistics Canada, with AECB contributing 70% of the total cost.)

Proponent	RPD, UBC (S. Sheps), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$45k	$45k	$0k	$90k

Earlier Directly-Related Contracts and Funding:

7.132.1 Computerized Format for Pooling Radiation Exposure Records

It is proposed to transform the records of past exposures to both radiation and other carcinogens into a computerized format. Initially, the study will be confined to exposure records of Atomic Radiation Workers in Canadian nuclear power stations.

There is an increasing need for an international standardization of radiation exposure records to facilitate pooling of data for follow-up studies of persons occupationally exposed to relatively low doses of ionizing radiation. International experts agree that the data from various countries should be pooled together and analyzed comprehensively in order to arrive at more statistically significant risk estimates for radiation-induced cancers. Since Canada is a leader in mortality surveillance programs involving nuclear power station workers, upgrading of the data base into a universal computerized format is very appropriate.

The results of this study will enable the AECB to pool the exposure data of Canadian nuclear power station workers with similar data from other countries, and facilitate more comprehensive risk estimates for radiation-induced cancers and other effects.

Proponent	RPD, HES, UBC (T.W. Anderson)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$45k	$30k	$0k	$75k

Earlier Directly-Related Contracts and Funding:

7.133.1 Bone Cancer from Radionuclide Intake

It is proposed to conduct an epidemiological study of bone cancer incidence among Canadian children and young adults exposed to radium and other bone-seeking radionuclides in drinking water and food. In the first phase of the study, radium and other bone-seeking radionuclides in typical milk and food samples, obtained from areas where well water is used for irrigation purposes, will be measured. In a subsequent phase, a detailed case-control study of bone cancer incidence, in relation to total radium and other radionuclide intake, will be investigated.

A preliminary study of bone cancer incidence among Ontario residents has identified a suggestive association between the incidence of excess bone cancer and exposure to concentrations of radium, in well water, which are higher than the provincial average. Although the level of radium in the well water of all bone cancer cases was less than the National Health & Welfare-recommended maximum concentration of 1 Bq/L, the total intake of radium and other radionuclides, mainly dietary intake, should be measured to derive a relationship between the total intake of these radionuclides and the incidence of bone cancer.

The results of this study are expected to provide a quantitative relationship between excess bone cancer and total radium and other radionuclides intake. (This is expected to be a joint study with NHW, Ontario Ministry of Labour (OML), Ontario Ministry of the Environment and the Ontario Cancer Treatment and Research Foundation (OCTRF) at a total cost for both phases of $900K, of which the AECB portion would be about $120K, approximately $60K of which is expected to be for Phase I and the balance for Phase II.)

Proponent	RPD, OCTRF, OML (M. Finkelstein)
Technical Advisor/Evaluator	RPD (F. Horvath)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$40k	$40k	$40k	$120k

Earlier Directly-Related Contracts and Funding:

7.134.1 Threshold Effect of CNS Defects Due to In Utero Exposure

It is proposed to investigate, in a laboratory study, whether or not there exists a threshold effect for defects on the developing central nervous system (CNS) following in utero exposure to low doses of ionizing radiation, by measuring the ratio of brain to body weight of a suitable animal (newborn) as a function of doses received in utero.

Recent findings of the study of A-bomb survivors in Hiroshima and Nagasaki seem to suggest the possibility of the existence of a threshold for radiation-induced defects on the developing central nervous system, at very low doses. The results of some animal studies have also raised the possibility of the existence of a threshold for defects on the central nervous system for doses between 50-100 mSv received in utero.

The results of the study will be used to resolve the controversy about the existence of a threshold effect for radiation-induced defects on the central nervous system. In addition, the results will be used to improve the radiation protection practices for female Atomic Radiation Workers in Canadian nuclear facilities and radioisotope laboratories. (This is expected to be a joint study with the University of Texas, U.S. National Institutes of Health, and the Atomic Energy Control Board. The total cost of the study is about $275K, with an AECB contribution of $80K.)

Proponent	RPD, HES, U. of Texas (W. Schull)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	V. Elaguppillai
Review Panel	1
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$40k	$40k	$0k	$80k

Earlier Directly-Related Contracts and Funding:

7.142.1 Mortality Analysis of the Fluorspar Miners from 1985-1988

It is proposed to update the mortaltiy analysis of the fluorspar miners in St. Lawrence, Newfoundland, from 1985 to 1988. The risk of lung cancer per unit exposure to radon daughters will be recalculated using the additional mortality information and previously estimated exposures to radon daughters.

Since the previous analysis of lung cancer mortality to 1984, more deaths have occurred among fluorspar miners as a result of natural aging of the cohorts. Since the fluorspar miners were in a unique situation, in which they received neither exposure from gamma radiation nor from radioactive dust, it is important to analyze their mortality data to obtain improved risk estimates for lung cancer in a 'pure' radon daughter environment.

It is anticipated that the results of this study will further improve the risk estimates for lung cancer from exposure to radon daughters in the absence of gamma radiation and radioactive dust. (This is expected to be a joint project with the Department of National Health and Welfare and Statistics Canada.)

Proponent	RPD, HES, NHW (D. Wigle), Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (S. Ching)
Project Manager	V. Elaguppillai
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$15k	$25k	$10k	$50k

Earlier Directly-Related Contracts and Funding:

7.091.1	$170000	$0	$0			$170000

7.143.1 Canadian Cancer Data Base

It is proposed to link internally the Canadian Cancer Data Base file to identify multiple records of cancer incidence for the same individual. In addition, a set of microfiche of the Canadian Cancer Data Base will be created in various format sequences to facilitate manual checking of the results of the proposed study.

The reason for proposing this approach is to reduce the labour required when the cancer data files are being used in the follow-up of radiation studies, including the fluoroscopy study, the Eldorado Nuclear Limited cohort, and Atomic Energy of Canada Ltd. study.

The results of this study will help to determine whether the occurrence of cancer, where radiation was present, is significantly higher in a particular study group compared to others. (This project will be cost-shared with Statistics Canada. Statistics Canada is to contribute $10k and the AECB $20k).

Proponent	RPD, HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$0k	$0k	$20k

Earlier Directly-Related Contracts and Funding:

7.144.1 Development of an "Index of Harm" for Canadian Workers

It is proposed to fund a study of the procedures for integrating data from multiple sources for the purpose of developing an "index of harm" for members of the Canadian workforce. Past procedures have yielded experience with data bases in which information has been extracted from two matched files. For present purposes, the concept needs expansion to include integration of multiple sources by utilizing cross referencing and new data base techniques.

Over the past few years, for the purpose of assessing radiation risk, use has been made of: a) study cohort files; b) death records indicating endpoints (particularly cancers); c) cancer registrations; d) taxation records indicating members of cohorts still alive; and e) the social insurance number index file providing identifiers needed for follow-up. In order to develop the "index of harm" one needs also to add possible workplace accidents, genetic effects, delayed and chronic morbidity, including renal failure. The purpose of the present proposal is to prepare a coordinated plan, describing how to create a consolidated cross reference list for individuals between such files, rather than treating them mainly in a piece-meal fashion two at a time. New storage devices, new equipment (e.g., the expanding capabilities of personal computers), new data developments (e.g., the National Work Injuries and Accident Program, the Canadian Renal Failure Register) and data base packages (e.g., ORACLE or RAPID) will be examined. These new developments should be generalized and made to accommodate new data sources as they become available. Confidentiality and policies which need to be addressed in utilizing the required data source will be outlined.

It is anticipated that this study will provide AECB with: a) a brief view of recent "index of harm" literature, such as ICRP Nos. 27 and 45, along with examination of the feasibility of drawing suitable statistical data from Canadian sources; and b) recommendations for procedures for coordinating existing data collection and data base development in Canada in order to produce "index of harm" data for radiation and other industrial workers.

Proponent	RPD, HES, Statistics Canada (M. Fair)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

7.145.1 Screening Breast Cancer Patients for A-T Heterozygosity

It is proposed to fund a study to determine the percentage of women with breast cancer who are also carriers (heterozygotes) of ataxia telangiectasia (A-T), a recessively inherited multisystem disorder that results in a predisposition to lymphoproliferative malignancies and marked higher radiosensitivity, as demonstrated by intolerance to conventional radiotherapy. To this end, a prospective case-control study will be conducted on 200 breast cancer patients presenting pre-operatively at the Cross Cancer Institute, in Alberta, and an equal number of age- and parity-matched (parity in this context refers to the number of children the subject has given birth to) controls selected from healthy women undergoing noncancer-related gynecological examinations.

This study is proposed because it has been predicted (Swift, M., et al., N. Engl. J. Med. 316:1289, 1987) that as many as 18% of all women with breast cancer may be carriers of A-T. However, due to the rarity of A-T patients, it is estimated that only approximately 1.4% of the entire population (men and women taken together) are A-T carriers. Moreover, researchers have demonstrated that the radio-response of cultured fibroblast and lymphoblastoid cell lines from A-T heterozygotes (i.e., parents of A-T patients) to chronic Co-60 gamma irradiation indicates a heightened sensitivity, compared with cell lines from normal controls. Therefore, female carriers of A-T may make a disproportionately large contribution to the overall breast carcinoma group, and thereby skew the distribution of risk for radiogenic breast cancer.

It is anticipated that the findings of this work will refine the assessment of risk of breast cancer from exposure to low level radiation. (This study will be cost-shared between the AECB (35%), the Alberta Cancer Board (60%), and the Ataxia Telangiectasia Medical Research Foundation of America (5%).)

Proponent	RPD, HES, Cross Cancer Institute (M.C. Paterson)
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	E. Rabin
Review Panel	8
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$50k	$50k	$50k	$150k

Earlier Directly-Related Contracts and Funding:

7.148.1 In-Vitro Study of the Combined Effects of Radiation and Chemical Substances

It is proposed to carry out an in-vitro experiment (on yeast cells) to investigate the combined effects of exposure to several types of chemical subtances found at nuclear facilities and low level ionizing radiation delivered at doses in the occupational range.

This project is proposed because workers at Canadian nuclear facilities are exposed to chemical substances which have not been taken into account in a number of epidemiological studies, as potential factors in the induction of cancer among radiation workers. This project is proposed as a follow-on to the recently completed Project 7.107.1, "A Feasibility Study on the Identification and Determination of Exposure Levels of Non-Radiological Carcinogenic Substances at Canadian Nuclear Facilities".

It is anticipated that this project will help to assess more accurately the health risks from exposure to radiation only as compared to that from radiation interacting with chemical subtances. The nature of these interactions may be additive, antagonistic or synergistic. Furthermore, a long range goal is to carry out epidemiological studies on the influence of chemical substances on the induction of cancer among radiation workers. (AECL-CRNL is proposing to cost share this project with the AECB on a 50%-50% basis. The overall cost of this project is estimated at $80k.)

Proponent	RPD, HES
Technical Advisor/Evaluator	RPD (M. Measures, C. Létourneau)
Project Manager	K.P. Ho
Review Panel	
Contractor	
Principal Investigator	
Category	3

	Past	89/90	90/91	91/92	Future	Total
	$0k	$0k	$30k	$10k	$0k	$40k

Earlier Directly-Related Contracts and Funding:

7.107.1	$46000	$0	$0			$46000

7.149.1 Biological Dosimetry

It is proposed to examine a spectrum of biological indicators, such as cytogenetic (e.g. formation of micronuclei) and immunochemical changes in blood cells, reactive products in DNA, protein, lipid and polysaccharides, and stable biophysical changes in biological samples (e.g. hair, teeth etc.), for their suitability for measuring the extent of inadvertent or accidental exposure of individuals, and their accumulation of chronic exposure to ionizing radiation. Phase 1 of the study will consist of a detailed review and critique of existing techniques of biological dosimetry (based on currently available literature), including an assessment of their sensitivity, accuracy, reproducibility of results, and other important parameters with respect to monitoring low-level radiation exposure. Phase 2 will consist of the development and testing of a prototype biological dosimeter to establish the dose-response relationship, dose-rate effects, effects of dissolved oxygen, other environmental effects of importance in a practical biological dosimeter, convenience of use, stability, sensitivity (including the influence of the prevalence of the biological indicators in unexposed individuals), reliability, reproduciblity and overall efficacy.

This study is proposed because, for accidental exposure, biological dosimetry is often all that is available, and chromosome aberration analysis does not have sufficient sensitivity or accuracy. In addition, the possibility of using these new methods for determining cumulative dose over many years is of interest.

It is anticipated that the results of this study i.e. the development of a practical biological dosimeter, would provide AECB staff with a means of assessing the dose to licensee staff who are accidently exposed to ionizing radiation, whether they are ARWs or not, and, in addition, possibly corroborate or refute anomalous dose data obtained from currently used personnel dosimeters. (The study is to be jointly funded by the AECB and AECL on an equal cost-sharing basis: AECB $100k, AECL $100k)

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$40k	$30k	$30k	$100k

Earlier Directly-Related Contracts and Funding:

7.150.1 Site-Specific Assay for Mutation in Human Cells

It is proposed to develop a site-specific (in DNA fragments) and universally applicable assay for mutagenesis in human cells.

Estimates of the genetic harm from exposure of human populations to mutagens, including ionizing radiation, by direct or indirect methods, usually involve extrapolated inferences from simpler experimental systems or from the mouse-specific locus mutation assay. The 1988 UNSCEAR review of the genetic risks from exposure to ionizing radiation made a number of suggestions for future studies that support the development of a general, non-selective, site-specific mutation assay for human or other organisms.

It is anticipated that a successful method for evaluating mutation frequency in human cells will make practicable studies on spontaneous and induced mutation rates, and the influence of these on DNA repair systems and other intracellular processes, which in turn will furnish information that is pertinent to assessing the genetic hazards from exposure to ionizing radiation. This information may impact on the component of the estimate of risk from exposure to ionizing radiation that is due to the genetic insult, in humans. (The study is to be jointly funded by the AECB and AECL on an equal cost-sharing basis: AECB $30k, AECL $30k)

Proponent	RPD
Technical Advisor/Evaluator	RPD (C. Pomroy)
Project Manager	E. Rabin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$20k	$10k	$0k	$30k

Earlier Directly-Related Contracts and Funding:

8.103.1 Testing of Foam Used in Packaging for Shock and Thermal Absorbency

It is proposed that samples of polyurethane foam, both cast in situ and from blocks, be tested for: a) energy absorption; b) load/deflection; and c) thermal resistance. Foams of different densities and from different manufacturing processes will be tested. It is expected that the load/deflector tests will be performed statically, but energy absorption should take into consideration dynamic loading.

Over the last decade there has been considerable use of polymer foam in the construction of packaging for radioactive material. This foam is used in three basic applications: impact limitation, thermal insulation, and moisture absorption. Foam is often made "in situ", filling fully closed cavities that exist in the structure. It is also supplied in bulk blocks and shapes. By alterations in materials, catalyst quantities and processes, it is possible to obtain a foam with certain required properties. Little information is available on the controlling parameters and the resulting properties. This makes difficult the enforcement of quality assurance of packaging by AECB staff.

From the results of these tests, AECB staff would be able to assess more accurately information supplied supporting applications for package and device approval. In addition, manufacturing controls can be determined with which to obtain the necessary level of quality assurance.

Proponent	RTD
Technical Advisor/Evaluator	RTD (D. Joseph)
Project Manager	R. Avadhanula
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$35k	$0k	$0k	$35k

Earlier Directly-Related Contracts and Funding:

9.102.1 Review of Crisis Management Methods

It is proposed to conduct a review of AECB operations and corporate planning and, based on the latest developments in crisis management, to determine which elements of crisis management should be included in corporate planning, and in the preparation of a crisis management manual.

Although there are AECB documents that deal with emergency response at the working level (e.g. duty officer's handbook, divisional operating procedures), there is no corporate document that deals with broader questions such as: the establishment of a crisis team; communications with the public, who handles it, and how; chain of command in the absence of someone in the management structure; interaction with other government agencies; role of the AECB Emergency Response Coordinator.

The results of this review will assist AECB staff in updating corporate plans to address crisis management, and in preparing a detailed crisis management manual.

Proponent	EXEC
Technical Advisor/Evaluator	PCS (T. Diamantstein)
Project Manager	D.J. Martin
Review Panel	
Contractor	
Principal Investigator	
Category	3

Past	89/90	90/91	91/92	Future	Total
$0k	$0k	$25k	$0k	$0k	$25k

Earlier Directly-Related Contracts and Funding:

FUNDING
OF
AECB REGULATORY RESEARCH & SUPPORT PROGRAM
BY MISSION OBJECT ($K)

(FY 90/91 ALLOCATION: $3,750K)

MISSION OBJECT		FY 1990/91 ALLOCATION ($K)		
		CATEGORIES 1* & 1 & 2	CATEGORY 3	TOTAL
2	NUCLEAR REACTORS	1,946	1,245	3,191
3	OTHER FUEL CYCLE FACILITIES, GENERAL	612	290	902
4	URANIUM MINES AND MILLS	483	175	658
5	WASTE MANAGEMENT	280	135	415
6	NON FUEL CYCLE APPLICATIONS	85	43	128
7	HEALTH PHYSICS	296	538	834
8	TRANSPORTATION	-	35	35
9	REGULATIONS & REGULATORY PROCESS DEVELOPMENT	110	25	135
	TOTAL	3,812	2,486	6,298

LIST OF REVIEW PANELS FOR REGULATORY RESEARCH & SUPPORT PROGRAM PROJECTS

1. RADIATION-INDUCED DEVELOPMENTAL DEFECTS

Project Manager: V. Elaguppillai

Planned:

Effects on Central Nervous System from In Utero Exposure (7.106.2)

Threshold Effect of CNS Defects Due to In Utero Exposure (7.134.1)

Mechanism of Radiation-Induced Mental Retardation (7.135.1)

2. EPIDEMIOLOGY

Project Manager: V. Elaguppillai

In Progress:

Full-Scale Epidemiological Study of Thyroid Cancer from I-131 Exposure (7.119.2)

Planned:

Mortality Analysis of Beaverlodge Uranium Miners from (4.118.2)

Calculation of Lung Dose following Fluroscopic Examination (6.114.1)

Mortality Analysis of Persons Subjected to Fluoroscopic Examination (6.114.2)

Hospital Record-Keeping System for Epidemiological Studies (7.117.1)

Study of Childhood Cancer following Maternal X-Irradiation (7.137.1)

3. INHALATION STUDIES

Project Manager: P.J. Duport

In Progress:

Study of the Health Effects of Inhaled Uranium Ore Dust (4.101.1)

4. DOSIMETRIC MODELS

Project Manager: P.J. Duport

In Progress:

Evaluation of Data and Models on Uranium Metabolism - Europe (3.111.1)

Evaluation of Data and Models on Uranium Metabolism - North America (3.111.2)

Planned:

Absorbed Fraction of Ingested Uranium in Humans (3.103.1)

5. LUNG SOLUBILITY STUDIES

Project Manager: K.P. Ho

In Progress:

Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities (4.103.2)

Project Manager: P.J. Duport

Planned:

Influence of Macrophages on Dissolution of Uranium Compounds (3.123.1)

6. RELATIVE BIOLOGICAL EFFECTIVENESS (RBE)

Project Manager: E. Rabin

Planned:

RBE of Gamma Rays Delivered at Low Dose Rates (7.141.1)

7. BRONCHIAL EPITHELIUM

No 1990/91 Panel

8. RADIOSENSITIVITY OF BIOLOGICAL SYSTEMS

Project Manager: E. Rabin

Planned:

Screening Breast Cancer Patients for A-T Heterozygosity (7.145.1)

9. URANIUM TOXICITY — No 1990/91 Panel

10. HYDROGEOLOGY — No 1990/91 Panel

11. ENVIRONMENTAL PATHWAYS

Project Manager: R. Avadhanula

In Progress:

Transfer of Radionuclides to Human Milk - Phase 3 Field Study (3.106.3)

Planned:

Radionuclide Concentrations in Fish: Phase I Screening (5.127.1)

12. SOFTWARE RELIABILITY

Project Manager: D.E. Connelly

Planned:

Computer Software Quality Assurance (II) (2.089.2)

CASE Analysis Tools for Real-Time Software (2.102.1)

Self-Testing of Programmable Controllers & Microcomputers (2.130.2)

Estimating Software Reliability for Reactor Shutdown (2.134.1)

Evaluaton of Software Functional Specification Review (2.158.1)

Software Quality Assurance for Waste Disposal Models (5.115.1)

13. GEOCHEMISTRY — No 1990/91 Panel

14. SEVERE ACCIDENTS

Project Manager: A. Omar

Planned:

Detailed Analysis of Severe Accident Consequences (2.157.2)

15. NPP AGING

Project Manager: J. Pachner

Planned:

Ballooning of CANDU Pressure Tubes - Model Verification (2.184.2)

16. DEEP GEOLOGICAL DISPOSAL

Project Manager: J.L. Wallach

Planned:

Demonstration of the Feasibility of Directly Dating Quartz (3.101.2)

17. EXPOSURE EVALUATION

Project Manager: V. Elaguppillai

In Progress:

Evaluation of Exposure Records of Eldorado Uranium Miners (4.118.1)

18. EXPOSURES OF NON-MONITORED PERSONNEL

Project Manager: K.P. Ho

In Progress:

Radiation Exposures of Non-Monitored Hospital Personnel (6.105.1)

19. FOETAL DOSIMETRY

Project Manager: E. Rabin

Planned:

Transport of Compounds from Mother to Foetus (7.152.1)

20. CONTACT DOSIMETRY

Project Manager: E. Rabin

Planned:

Tritium Surface Contact Dosimetry (2.211.1)

21. NPP EQUIPMENT QUALIFICATION
(Environmental and Dynamic)

Project Manager: J.Pachner

Planned:

Pickering Seismic Safety Margin (Feasibility Study) (2.209.1)

22. SEISMIC HAZARD

Project Manager: J.L. Wallach

Planned:

Seismic Monitoring East and North of Toronto (2.217.1)

1990/91 Research Projects

2.089.2	Computer Software Quality Assurance (II)
2.101.1	Instrument Behaviour under Off-Normal Conditions
2.102.1	CASE Analysis Tools for Real-Time Software
2.111.1	International Piping Integrity Research Group
2.111.2	International Piping Integrity Research Group - 2
2.114.2	A Simulator for Evaluating Emergency Operating Procedures
2.118.1	Behaviour of the Calandria Structure under Severe Conditions
2.127.5	Statistically Valid Random Testing for Real-Time Software
2.128.3	Review of a BNPD Fire-Fighting Exercise
2.130.2	Self-Testing of Programmable Controllers & Microcomputers
2.133.1	Review of the SLOWPOKE Demonstration Reactor Control System
2.134.1	Estimating Software Reliability for Reactor Shutdown Systems
2.148.2	Molten Fuel/Moderator Interaction - Feasibility of Large Scale Tests
2.152.3	Tutorial Sessions for CATHENA Users
2.152.4	Five-Channel-per-Pass CATHENA Code for Darlington NGS
2.153.1	Computer Codes for Examining Circulation within Containment
2.155.1	Maintenance: Means and Methods
2.157.2	Detailed Analysis of Severe Accident Consequences
2.158.1	Evaluation of Software Functional Specification Review Techniques
2.162.2	Childhood Leukemia around Canadian Nuclear Facilities (Phase II)
2.165.1	Studies of Stability and Related Issues for Small Reactors
2.170.1	Reliability of Electrical Motors under Accident Conditions
2.171.1	Portable Information Processing for Quality Assurance Audits
2.172.1	Computer-Based Safety Interlocks for Research Accelerators
2.175.1	Pump Cavitation and Piping Vibration (I)
2.176.1	Software Functional Requirement Specification Techniques
2.177.2	Fuel Channel Refilling - Phase II
2.178.1	Critical Heat Flux Measurements in a Simulated Fuel Bundle
2.179.1	Performance of Steam Generator Emergency Water Injection
2.184.2	Ballooning of CANDU Pressure Tubes - Model Verification
2.188.1	Tissue Equivalent Proportional Counter
2.190.1	Selection of Safety Significant Components of Nuclear Power Plants for Aging Assessments
2.191.1	Review of Piping System Failures at Discontinuities
2.192.1	Effect of Sheath Strain on Critical Heat Flux
2.193.1	Studies of Hydrogen Combustion Phenomena in CANDU Nuclear Power Plants
2.195.1	Fracture Toughness of Fuel Sheath Material
2.196.1	Statistical Review of Pressure Tube Inspection Data
2.197.1	Fission Product Release at SLOWPOKE Reactors

2.198.1	Containment Performance under Severe Accidents
2.199.1	The Prevention, Mitigation and Accommodation of Water Hammer
2.200.1	A Safety Course for Pressure-Tube Type Reactors
2.201.1	Review of Reactor Safety Characteristics - Phase I
2.202.1	Severe Accident Source Term
2.203.1	Intermediate and Full Scale Tests on Hydrogen Burn Phenomena
2.204.1	Pressure Tube Rupture in A Closed Tank - Thermalhydraulic Loadings
2.205.1	Training Requirements for Authorized Operating Personnel
2.206.1	Methodology for Assessment of Training Programs
2.207.1	Guidelines for Examination Time Allocation
2.208.1	Review of Darlington Probabilistic Safety Evaluation Events Involving Operating Action
2.209.1	Pickering Seismic Safety Margin (Feasibility Study)
2.210.1	Participation in the USNRC Severe Accident Research Program
2.211.1	Tritium Surface Contact Dosimetry
2.212.1	Analysis of Voice Communications
2.213.1	Development of AECB Human Factors Guidelines
2.214.1	Review of Supervisory Functions in Nuclear Power Plants
2.215.1	Criticality Energy Release Rate in Uranium Solutions
2.216.1	Validation of Positive Void Effect
2.217.1	Seismic Monitoring East and North of Toronto
3.101.2	Demonstration of the Feasibility of Directly Dating Quartz (2)
3.103.1	Absorbed Fraction of Ingested Uranium in Humans
3.106.3	Transfer of Radionuclides to Human Milk - Phase 3 Pilot Study
3.111.1	Evaluation of Data and Models on Uranium Metabolism - Europe
3.111.2	Evaluation of Data and Models on Uranium Metabolism - North America
3.123.1	Influence of Macrophages on Dissolution of Uranium Compounds
3.124.1	Assessment of Errors in Airflow Measuring Instruments (U Mines)
3.125.1	Study of Chemical Toxicity of Uranium Hexafluoride
3.128.1	A Search for An Active Fault - Miramichi Area, N.B.
3.133.1	Carbon-14 in Food and in Excretions
3.134.1	RBE from a Microdosimetric Approach
3.135.1	Measurement of Tritium in Canadian Food Items
3.135.2	Dosimetry of Organically Bound Tritium Derived from Diet
3.139.1	Offset River Terraces in the Charlevoix Seismic Zone
3.144.2	Liquefaction Features in the Chicoutimi Area
3.146.1	Canadian Atmospheric Stability Indicators
3.148.1	Thorium Metabolism and Dosimetry - Literature Review
3.150.1	Different Biological End-Points to Study Radiation Effects
3.150.2	Effects of Radiation on Species Other than Man: Aquatic Organisms
3.151.1	Canadian Data Base for Radionuclide Transfer in the Environment
3.152.1	Production of Public Information Material on the Effects of Radiation
3.153.1	Evaluation of Microdosimetric and Distributional Aspects of Tritium
3.154.1	Optimization of Doses between Atomic Radiation Workers and the Public

3.155.1	Validation of Environmental Pathways Analysis Models
3.156.1	An Analysis of Brittle Structures in the Saguenay Earthquake Areas
3.157.1	A Field Evaluation of Convoluted Laminations
3.158.1	Geophysical Studies in Prince Edward County, Ontario
3.159.1	The Aspy Fault in Nova Scotia
4.101.1	Study of the Health Effects of Inhaled Uranium Ore Dust
4.103.2	Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities
4.106.3	Ontario Miners Mortality Study - Phase III
4.106.4	Ontario Miners Mortality Study - Annual Update
4.108.1	Intercomparison of Aerosol Sampling Instruments
4.112.1	Electrical Charge of Radioactive Aerosols in Uranium Mines
4.113.1	Tracer Gas Method for Assessing Ventilation Efficiency
4.117.1	Evaluation of Long-Lived Dust Exposures from Silica Samples
4.118.1	Evaluation of Exposure Records of Eldorado Uranium Miners
4.118.2	Mortality Analysis of Beaverlodge Uranium Miners from 1981-1987
4.119.1	Evaluation of Mine Ventilation Monitoring Devices
4.120.1	Sensitivity of Bronchial Epithelial Cells to Alpha Radiation
4.125.1	Exposure-Rate Effectiveness for the Induction of Lung Cancer
4.126.1	Computerized Mortality Search Procedures
4.129.1	Temporal Variation of Airborne Radioactivity in Mines
4.130.1	Evaluation of Radon Daughter Exposures of Port Radium Miners
4.130.2	Mortality Analysis of Port Radium Uranium Miners (1950-1988)
5.115.1	Software Quality Assurance for Waste Disposal Models
5.127.1	Radionuclide Concentrations in Fish: Phase I Screening Program
5.129.1	Decommissioning of Open Pit Mines - Literature Survey
5.134.1	International Conference on Transport Processes in Aquifers
5.135.1	Frost Evolution in Tailings
5.136.1	Hydrology of Quirke and Panel Tailings Basins
5.137.1	Study of Radionuclides in the Lichen-Caribou-Man Food Chain
5.138.1	Review of Uranium Solubilities
5.139.1	Dissolution of Fuel Matrix - Analog Studies
5.140.1	Link between Ore Bodies and Biosphere Concentrations of Metals
5.141.1	Review of Groundwater Dating and Its Relation to High Level Waste Disposal
5.142.1	Feasibility of Monitoring Tailings Sites Using Remote Sensing
6.102.1	Radiation Doses to Technologists from Radiotherapy
6.105.1	Radiation Exposures of Non-Monitored Hospital Personnel
6.113.1	Measurements of Radioactive Waste Disposal in Hamilton
6.114.1	Calculation of Lung Dose following Fluoroscopic Examination
6.114.2	Mortality Analysis of Persons Subjected to Fluoroscopic Examination
6.115.1	Development of an Extremity Dosimeter: Ring Dosimeter
7.093.1	Epidemiology of Lung Cancer Mortality in Canadian Mining Communities

7.093.2	Epidemiology of Lung Cancer in a Canadian Mining Community
7.101.1	The Canadian National Dose Registry Study
7.106.2	Effects on Central Nervous System from In Utero Exposure
7.116.1	Cancer Morbidity Follow-Up Feasibility Study
7.117.1	Hospital Record-Keeping System for Epidemiological Studies
7.118.1	Selection of Control Groups for Epidemiological Studies
7.119.2	Full-Scale Epidemiological Study of Thyroid Cancer from I-131 Exposure
7.122.1	Computerized Linkage of National Cancer Incidence Data
7.126.1	Use of An Employee Identification Questionnaire and Guide
7.127.1	Dose Response of Human Lymphocytes to Radiation and Chemical Carcinogens
7.128.1	The Relative Impact of Radiation-Induced Genetic Disorders
7.132.1	Computerized Format for Pooling Radiation Exposure Records
7.133.1	Bone Cancer from Radionuclide Intake
7.134.1	Threshold Effect of CNS Defects Due to In Utero Exposure
7.135.1	Mechanism of Radiation-Induced Mental Retardation
7.137.1	Study of Childhood Cancer following Maternal X-Irradiation
7.141.1	RBE of Gamma Rays Delivered at Low Dose Rates
7.142.1	Mortality Analysis of the Fluorspar Miners from 1985-1988
7.143.1	Canadian Cancer Data Base
7.144.1	Development of an "Index of Harm" for Canadian Workers
7.145.1	Screening Breast Cancer Patients for A-T Heterozygosity
7.148.1	In-Vitro Study of the Combined Effects of Radiation and Chemical Substances
7.149.1	Biological Dosimetry
7.150.1	Site-Specific Assay for Mutation in Human Cells
7.152.1	Transport of Compounds from Mother to Foetus
7.153.1	RBE of Tritium and Co-60 Gamma Rays at Low and High Dose Rates
8.103.1	Testing of Foam Used in Packaging for Shock and Thermal Absorbency
9.102.1	Review of Crisis Management Methods
9.103.2	Implementation of a New File Classification System
9.103.3	Implementation of New Information Management Plan
9.106.2	A Review of the UCP System
9.116.1	The Concept of "Environment" in a Legal Context
9.117.1	Development of a Security Program for EDP at the AECB

STANDARD ABBREVIATIONS
AECB ORGANIZATIONAL UNITS

SIGLES COURANTS DES UNITÉS
ORGANISATIONNELLES DE LA CCEA

Office of the President	OPR	Bureau du Président
Advisory Committee on Radiation Protection	ACRP	Comité consultatif de la radioprotection
Advisory Committee on Nuclear Safety	ACNS	Comité consultatif de la sûreté nucléaire
Secretariat	SEC	Secrétariat
Secretary to the Board	SEB	Secrétaire de la Commission
Office of Public Information	OPI	Bureau d'information publique
Planning and Coordination Section	PCS	Section de la planification et de la coordination
Advisory Committee Secretariat	ACS	Secrétariat des groupes consultatifs
Legal Services Unit	LSU	Services juridiques
Official Languages Advisor	CLO	Conseiller en langues officielles
Medical Liaison Officer	MLO	Agent de liaison médical
Directorate of Reactor Regulation	DRR	Direction générale de la réglementation des réacteurs
Power Reactor Division A	PRDA	Division A des réacteurs nucléaires
Power Reactor Division B	PRDB	Division B des réacteurs nucléaires
Operator Certification Division	OCD	Division de l'accréditation des opérateurs
Studies and Codification Division	SCD	Division des études et de la codification

Directorate of Fuel Cycle and Materials Regulation	DFC	Direction générale de la réglementation du cycle du combustible et des matières nucléaires
Radioisotopes and Transportation Division	RTD	Division des radio-isotopes et des transports
Compliance Services and Laboratories Division	CSLD	Division des contrôles et des laboratoires
Uranium Facilities Division	UFD	Division des installations d'uranium
Waste Management Division	WMD	Division de la gestion des déchets
Directorate of Assessment and Analysis	DAA	Direction générale de l'évaluation et de l'analyse
Safety Evaluation Division	SED	Division de l'évaluation de la sûreté
Components and Quality Assurance Division	CQAD	Division des composants et de l'assurance-qualité
Radiation Protection Division	RPD	Division de la radioprotection
Directorate of Research and Safeguards	DRS	Direction générale de la recherche et des garanties
Safeguards and Security Division	SSD	Division des garanties et de la sécurité
Health and Environmental Effects Section	HES	Section des effets sur la santé et sur l'environnement
Safety and Safeguards Section	SSS	Section de la sûreté et des garanties
Directorate of Administration	PAB	Direction générale de l'administration
Administration Division	ADD	Division de l'administration
Finance Section	FIS	Section des finances
Personnel Section	PES	Section du personnel
Information Management Section	IMS	Section du traitement de l'information